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INTRODUCTION TO HUMAN FACTORS
AND
WIDE AREA NETWORKING

by

John G. Clarke

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Co-Advisor: Eric S. Theise, PhD
Co-Advisor: Gary K. Poock, PhD

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The Human-Systems Interaction Course taught at the Naval Postgraduate School is an introduction to the human-systems interface, that part of the system which the human uses to provide input to and receive feedback from the system. This thesis will provide a basic introduction to those factors which must be considered when designing today's complex military systems. Additionally, this thesis will provide an introduction to the Internet -- a worldwide network of computers and smaller networks. Students will use the Internet to gather information, access remote programs, and communicate with other personnel around the world. This thesis is only an introduction to both of these complex topics; further research is possible into any of the topics discussed. Appendix A provides a number of basic exercises intended to introduce the concepts discussed in the body of the thesis.

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Introduction to Human Factors
and
Wide Area Networking

by

John G. Clarke
Captain, United States Air Force
B.S.E.E., University of Massachusetts, 1983

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Author:

John Gordon Clarke

Approved by:

Eric S. Theise, PhD, Thesis Co-Advisor

Gary K. Poock, PhD, Thesis Co-Advisor

Carl R. Jones, PhD, Chairman,
Department of Joint Command, Control, and Communications

ABSTRACT

The Human-Systems Interaction Course taught at the Naval Postgraduate School is an introduction to the human-systems interface, that part of the system which the human uses to provide input to and receive feedback from the system. This thesis will provide a basic introduction to those factors which must be considered when designing today's complex military systems. Additionally, this thesis will provide an introduction to the Internet -- a worldwide network of computers and smaller networks. Students will use the Internet to gather information, access remote programs, and communicate with other personnel around the world. This thesis is only an introduction to both of these complex topics; further research is possible into any of the topics discussed. Appendix A provides a number of basic exercises intended to introduce the concepts discussed in the body of the thesis.

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I. INTRODUCTION

Early in history, humans began to develop tools to increase productivity. With the development of the first stone hammer, humans used human factors practices. Handles were added to improve the hold and leverage from the stone. Over the years humans have continued to improve the design of hammers and now there are air-powered hammers which provide a large amount of force with little discomfort to the human using them. Most people have had the experience of using some piece of equipment, whether it be a can opener at home or a sophisticated computer at work, and they've said to themselves "why did they make it like this?" Anyone who has made that kind of statement has, in some sense, performed a human factors analysis of the equipment they were using.

A large number of military systems are becoming increasingly complex and as such, the tasking on the human operator is increasing rapidly. This growth in the demands on humans requires that increased awareness be directed towards the human-systems interface to ensure that the interface itself does not make the task at hand unmanageable.

Historically, the design and development of military systems has focused on the performance factors for the system itself. These factors include such things as circular error probable (accuracy), range, speed, and lethality for weapons systems and processing speed, data transfer rate, and storage capacity for communications and computer systems.

While the previously mentioned factors are important, they are not the only things affecting the performance of the system. The human-system interface, that portion of the system used to provide input and output to the system, can significantly impact the perceived and actual performance of the system.

Human factors involves studying how humans interact with their environment using this information to design an develop tools in such a way as to improve their interaction. This chapter will investigate the objectives of human factors and also define what human factors is and what it isn't.

A. WHAT HUMAN FACTORS IS

Human factors focuses on human beings and their interaction with products, equipment, facilities, procedures, and environments used in work and everyday living [Sanders and McCormick, 1987, p. 4]. There are two generally recognized objectives of human factors engineering: 1) to improve the

effectiveness and efficiency of work and other activities and 2) enhancement of certain desirable human values, including improved safety, reduced fatigue and stress, increased comfort, greater user acceptance, increased job satisfaction, and improved quality of life [Sanders and McCormick, 1987, p. 4]. Simplified, this means that human factors is used to design tools which make it easier and more pleasant for humans to use them.

The application of human factors to human-system interfaces requires analysis of a number of basic elements. First the desired product or service of the system must be analyzed to determine the best way to implement the system. Once this has been accomplished the feedback mechanism must be developed; this involves determining what information must be presented and the best way to present the information to the user. The final stage in the analysis of the system is to determine what actions the user must take to activate and control the system and the design the method for implementing the desired commands. After above factors have been initially designed, the system developer must then consider the interaction of these principles and modify the design to ensure they act in consonance. Human factors engineering includes the study of the size, shape, and appearance of the human-system interface. The method of presenting information to the user is another area of increased importance.

The proper application of human factors principles to the development of systems not only increases the utility of the system, it reduces the chances for catastrophic error and failure of the system to perform the task or tasks which it was ultimately designed for. Human factors includes the study of human performance under stress and the occurrence of human errors in these conditions. The results of these studies are used to improve the design of all systems which have some human interaction required, whether that interaction be some physical effort on the part of the human or the simple task of reading a display to determine the current state of the system.

B. WHAT HUMAN FACTORS IS NOT

The previous paragraph may have made human factors seem like the basic application of common sense or the application of checklists and guidelines in the development of the systems. Human factors is neither of these. Nor is it simply applying one's self as the model for the system development.

Human factors does not attempt to modify the behavior of the user to fit the system, rather it attempts to change the design of the system to accommodate the inherent capabilities and limitations of the human. A good human-system interface does not simply fit the desires or idiosyncracies of a single

user, it must be designed to allow all intended users to interact with the system with acceptable degrees of success.

This thesis will give a brief introduction to human-systems interface importance in systems design and development and provide a reference tool which can be used as a stepping stone to further understanding of human-systems interface issues. The issues discussed will include systems design factors as well as human capabilities and limitations and their impact on systems performance.

II. AN INTRODUCTION TO THE HUMAN-SYSTEM INTERFACE

Any automated or non-automated system used by humans contains a human-system interface. The human-system interface is that part of the system which accepts input from and provides output to the human using the system; this could be a keyboard-display pair for a computer or the instrument panel in the driver's compartment of an automobile.

Humans judge the utility of a system by the ease with which it can be used as well as the clarity of the information provided by the system. Human stress factors impact the perceived usefulness of any military system; these include (1) time pressure, (2) fatigue, and (3) stress. The following sections will describe human capabilities and limitations as they impact military systems development and use.

A. HUMAN CAPABILITIES AND LIMITATIONS; HOW THEY IMPACT SYSTEMS DESIGN AND DEVELOPMENT

Sanders and McCormick state that;

> "We all depend on our auditory, tactual, and olfactory senses in many aspects of our lives, including hearing our children cry or the doorbell ring, feeling the smooth finish on fine furniture, or smelling a cantaloupe to determine if it is ripe." [Sanders and McCormick, 1987, p. 140].

These senses impact the design and development of systems humans use to accomplish everyday tasks. Vision, hearing, speech, memory, touch, smell and anthropometrics -- measurements of the human body to determine the differences in individuals, groups, etc., require careful consideration during the design phase of the systems in question to ensure these systems are usable. Additional human characteristics which limit human-systems interface performance include: information processing capabilities, error tendencies, learning capabilities, psychomotor skills, and the effects of stress. This chapter will investigate the potential effects of each of these factors on design of systems.

1. Hearing

Sound is around us in everyday life. As children we are conditioned to respond to our parent's voices. The tone of our parent's voices helped us to determine if they were happy, angry, or worried. As we matured, our ears developed sensitivities to different sounds and we learned to selectively filter out other sounds which were of less importance to us. Each of the sounds we have learned have characteristic frequencies which are caused by the vibrations of the source of the sound. The human ear is generally recognized to be sensitive to sounds in 20 cycles per second to 20 thousand Hertz (Hz).

Sound intensity also impacts how we perceive sounds, high intensity sounds generally get more attention than low intensity sounds. Additionally, low intensity sounds may not be perceived due to other sounds (noise) in our environment. The intensity of sound is associated with the human sensation of loudness [Sanders and McCormick, 1987, p. 142]. Sound intensity is measured in units of power per unit area, the most common measure being the decibel (dB). Measuring the sound intensity at the source is currently not possible but the measurement of the change in air pressure (sound pressure) caused by the sound is possible and therefore is used as a measurement. Sound pressure in dB is defined as:

$$SPL\ (dB) = 10\ Log_{10}\frac{P_1^2}{P_0^2} = 20\ Log_{10}\frac{P_1}{P_0}$$

where P_1 = the sound pressure of the desired sound

P_0 = the sound pressure of the reference sound

These measurements are used to determine the long term and short term effects of sound on the human ear and provide a basis for designing systems which produce both intentional and unintentional sounds. Intentional sounds (i.e. tones and synthesized sounds) are called auditory displays while unintentional sounds include engine noise in the boiler room of a ship or the clatter of a teletype machine printing out messages in the Combat Information Center. Auditory displays must be designed to be understood under operational conditions

TABLE I OSHA Recommended Noise Exposure Limits

Hours of Exposure	Sound Level dB(A)
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

which include intentional and unintentional sounds produced by collocated equipment.

Auditory displays present information by generating intentional sounds to indicate the status of the system or to warn of an impending action, failure, or safety hazard. Auditory displays are useful when visual and tactile (touch related) displays are not practical. The information presented by auditory displays is most useful when the information being presented is immediate, short, temporary, and/or continuously updated. Auditory displays also are very useful when lighting or other restrictions prevent visual displays from being used. When a fighter pilot is engaged in

combat, the amount of information which must be presented is immense. In order to reduce the amount of visual information which must be processed, tones are used to indicate different conditions. A pilot may be warned of enemy missile lock on their aircraft by a high frequency warbling tone in their headset. Conversely they may get a different frequency steady tone when their missile has obtained a fire control solution on an enemy aircraft. Another example of an auditory display in aircraft situations is the use of voice synthesis to present important information to the pilot. A synthesized voice will inform the pilot of low fuel conditions, dwindling ammunition, and a number of other important conditions. This information is presented to the pilot without the pilot continuously having to scan the instrument panel - a task which takes critical seconds away from the engagement of the enemy.

2. Sight

Sight is another very important human sense; it allows humans to identify their surroundings and to gather information and navigate around this environment. Human sight is

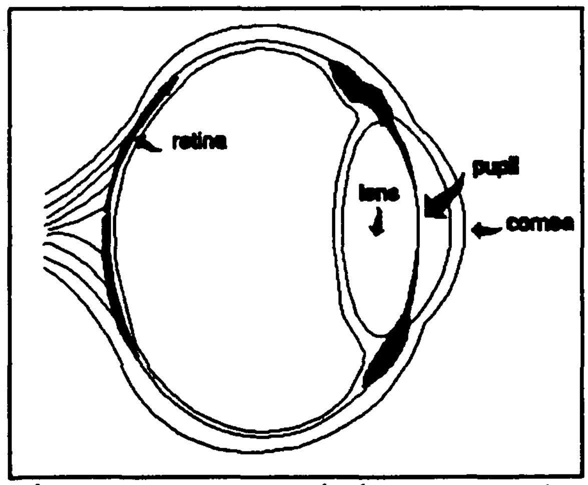

Figure 1 Composition of the Human Eye

limited by the physical composition of the eye which is illustrated in Figure 3. Light passes through the cornea, pupil, and lens enroute to the retina which converts the image to neural signals which are transmitted by the optic nerve to the brain. The brain then interprets these signals and the image is "seen" by the human.

The retina is composed of two types of receptors; cones and rods. Cones are sensitive to color and are used in brightly illuminated situations while the rods are sensitive to dim illumination (they are not color sensitive). The rods are primarily used to determine shapes and movement under dimly lit conditions and are the primary receptors used in night vision.

The eye adapts slowly to conditions of low illumination and requires a period of readjustment after exposure to bright lights. Once the eye has adapted to conditions of darkness exposure to bright light temporarily causes a reduction of visual acuity. The illumination of aircraft cockpits and Combat Information Centers has been carefully studied over the years to improve human performance in these environments. In order to the loss of visual acuity due to the ambient lighting, aircraft cockpits are lit using red illumination to take advantage of the reduced sensitivity of the eye to red light. This allows pilots to scan the

instruments and then immediately scan the sky without jeopardy of "flash blindness" which could have severe consequences at the high speeds travelled by aircraft.

Studies have shown that the use of "nominal" white illumination combined with colored push buttons actually improved overall response times. This concept is employed in the CIC of some combatant ships and also in automobiles (except the Avanti which uses red illumination, possibly more for the "sex-appeal" than the practicality of the situation) [Kantowitz and Sorkin, 1983, p. 108].

Many types of displays are available for the presentation of information to the user. The following list [Bailey, 1989, p. 212] is an example of the display types currently in use:

- Fixed-scale/Moving-pointer displays
- CRTs
- Flat-Panel CRTs
- Light-Emitting diode (LED)
- Liquid Crystal Display (LCD)
- Plasma displays
- Electroluminescence (EL) panels
- Electrochromic displays
- Projection systems

• Digital Displays

Each of these display types are more suitable for use under different conditions. When the environment is well lit displays such as the LED are very difficult to read whereas the LCD and Fixed-scale/Moving pointer displays are quite readable. Conversely when the lighting conditions are low the choice of an optimal display might tend towards one with a self-contained light source (i.e. EL or LED displays).

Improvements in the technology used for displays is reducing the weight, improving the usability, and reducing the power requirements of these displays. Evidence of this fact can be seen in the "notebook" and "laptop" computer systems currently being marketed. These new low power, high resolution displays allow more information to be displayed in a smaller areas. The newer high resolution displays are also being integrated into the cockpits of fighter aircraft. The McDonnell Douglas F-15 aircraft is currently equipped with a multi-purpose color display (MPCD) which is used to display a varying set of information. The Joint Tactical Information Distribution System uses the MPCD to display information regarding all aircraft in the area. The MPCD displays uses a combination of text and color to display the flight characteristics of each aircraft as well as indicate the nature of the aircraft; friendly, neutral, unidentified, or

hostile. The MPCD also contains programmable buttons which allow the designers to set the function of each button based on the current application using the display.

The packing of large amounts of information into very small areas requires careful consideration of the method used to display the information. Information which is very important must be highlighted to allow easy recognition of the meaning of the information. This highlighting can be done through the use of colors, changing the size of the message, or the flashing of the information. Without this highlighting, the information would be considered to have the same importance as other information on the display and therefore might be ignored until it was no longer valid. In the military environment this could be fatal if the information presented related to an incoming Scud or surface-to-air missile. An operator may ignore the information while concentrating on another task such as updating the shift log to accurately reflect changes in status of the system.

One of the most useful display technologies being used by the military is the heads-up display (HUD). The HUD presents critical information to the pilot on the windscreen thereby reducing the amount of time the pilot must focus on in-cockpit displays. The information presented to the pilot on a HUD includes:

- Location of the enemy aircraft
- Weapons status - guns and missiles armed or "safe"
- Altitude
- Airspeed
- Pitch and roll of the aircraft relative to earth horizon

The combination of the HUD and the MPCD in the F-15 have greatly reduced the number of gauges and instruments which the pilot must scan to gather information regarding the air situation.

3. Speech

Speech can be used as input or output from computer devices and can be used to control equipment and machinery. The patterns of human voices are recorded, modeled, and stored for use in comparing with spoken phrases or for providing auditory output to the user. Today's computer systems operate on the principles of discrete signal levels, in order for speech to be used with these systems it must be converted to digital signals recognizable by the computer.

Digitization of speech is the conversion of the speech pattern from analog (continuous) signals to digital (discrete) signals. This digitization allows the storage of voice information in computer memory and the retrieval and playback of that voice pattern at a later time. Digitization allows

for random access of the stored speech which increases the speed at which the desired pattern can be found and replayed. The effective range of human speech is between 1000 and 3000 Hz and therefore frequencies below 600 Hz and above 4000 Hz can be filtered out with little effect on the outcome [Park, 1987, p. 64]. This significantly reduces the amount of computer memory required for the storage of digitized human speech. Distortion in the synthesized voice can make the voice unpleasant to listen to and unintelligible. To avoid this problem Park [Park, 1987, p. 64] suggests that the signal must be sampled at twice the bandwidth frequency (which is 3400 Hz if the above filters are applied) and at 32 levels of amplitude which requires five bits of computer memory per sample. The amount of computer memory required for one second of digitized speech using these factors is:

$$5\ bits \times 2 \times 3{,}400\ Hz \times \frac{1\ byte}{8\ bits} = 4250\ bytes = 4.25\ Kb$$

The sampling rate of speech can be reduced to allow for increased speed but this is at the sacrifice of some quality. Several common uses of digitized speech include speech recognition, speech generation, voice verification, and voice identification.

a. *Speech Recognition*

Speech recognition is the recognition of patterns of sounds "uttered" by the speaker. These patterns are then

converted into machine readable form for use by other applications such as entering data by voice instead of typing on a keyboard. Speech recognition systems are categorized based upon the recognition of *discrete speech* or *connected speech* and whether they are *speaker dependent* or *speaker independent*.

Each word or phrase spoken without pause is called an utterance. Discrete speech systems are capable of recognizing single utterances while connected speech recognition systems recognize individual words in an entire sentence with no pause necessary between the words.

Speech recognition systems are further categorized by dependence of the system on the person providing the voice input to the system. Speaker dependent systems require the user to train the system to "understand" their peculiar speech patterns and habits. Speaker independent systems are designed to be used by any number of users without prior training. Current speaker independent systems have a higher error rate than the equivalent speaker dependent systems and are relatively limited in the vocabulary which they will recognize. Speaker dependent systems are well suited to applications where the same individual will be using the system on a daily basis. These systems will increase their accuracy over time as the speech habits of the users are

"learned" by the system. Speaker independent systems are increasingly being used by companies performing market surveys and telephone sales offices where the same users do not use the system on a regular basis. As the field of speech recognition is improved the accuracies of all four types of systems will increase dramatically.

Several problems arise when speech recognition systems are used in the operational environment. External noise, changing stress levels, and variances in human speech patterns all contribute to the errors in the systems. Another problem which may affect the outcome of speech control systems is the proper identification of words which sound the same but have quite different meanings which are called homonyms. In the English language many homonyms occur in everyday conversations; the words "their", "there", and "they're" are examples of a set of homonyms. The following general guidelines will help in development applications using speech recognition systems;

- keep the vocabulary as small as possible
- use standard sentence constructions with information always transmitted in the same order
- avoid short utterances (use phonetic alphabets if necessary)
- familiarize the receiver with the words and sentence structure to be used

- Train the system as it will be used (including the environmental noise, possible levels of stress, etc)

- Use as many passes as possible when training the system; this will ensure an accurate voice model is built

- Speak the words slightly differently during each of the passes.

- Speak in a normal voice - don't shout or whisper at the system.

- Don't allow mistakes to be recorded as valid speech patterns.

If the above recommendations are followed when training a speech recognition system, the success rate of the system will be markedly improved. Additionally, while the system is being used the voice models must be saved after each use of the system; this will ensure that the models are updated with the current speech patterns and word models used on a regular basis.

b. Speech Generation Systems

The generation of speech without the use of captured voice patterns is another common use of digitized speech. Speech synthesis of this form is call synthesis-by-rule. A set of rules is developed which defines the basic elements of speech and the principles used to connect these elements into phrases. This type of synthesis is used in automobiles, appliances, and toys like the Texas Instruments Speak & Spell. [Sanders and McCormick, 1987, p. 187]

c. Voice Verification Systems

A second application of speech is the verification of a person's identity. This is accomplished by having the user identify who they claim to be, either through entry of a unique identification code or password. The system then samples the speech patterns of the individual and compares these against a stored pattern. If the patterns match within a definable tolerance the individual is allowed access to the room or computer system protected by the voice verification system.

d. Voice Identification Systems

The third application of voice controlled systems is the voice identification system. This system contains a database of all authorized users and will determine the correct identity of the person based upon their speech patterns. This system is typically slower than voice verification system due to the requirement for the system to search the entire database and compare the spoken phrase with all stored patterns. The advantages of this system are that it requires no additional action by the user and no passwords or identification codes need be memorized. The reduced tasking on the operator leads to preference for this system over those which require the user to carry a physical key or memorize a password to activate the system.

e. *Speech Systems as Input*

Speech recognition systems can be used to replace keyboard entry and are well suited to applications where the operator either has limited or no use of the hands or is occupied doing other tasks. Military applications of speech recognition systems are being investigated for the F-16 fighter and the Carrier Air Traffic Control Center (CATCC) [Jensen and Spegele, 1988] as well as other equally complex tasks.

Speech recognition systems have made great advances in recent years in allowing physically challenged people to access computers and other devices which were previously beyond their reach. A example of this is the "Butler-in-A-Box" system which allows voice control of appliances, lights, electrical outlets, the telephone, and even heating and air-conditioning systems. This system can easily be connected in any home or office environment. This system is a speaker dependent connected speech system which has a vocabulary of 250 words. After the initial training of the system the user "wakes-up" the box by a trained phrase and then executes the desired commands.

f. Speech Systems as Output

There are a number of applications where speech synthesis is used as output to provide information to the human. The most common application of speech synthesis today is the automated telephone directory assistance system. Additional uses of speech output is the auditory display of information to passengers of transport systems in the Atlanta International Airport. These systems provide information regarding the pending arrival or departure of trains and the blockage of the doors by some object (such as a human being). These systems are considered easier for the passengers to use than visual display due to the ease with which the information is provided to the passengers without having to stop and read a display terminal for the same messages.

4. Memory

Memory plays an important role in the use of any human-systems interface. The interface must be designed to allow the intended group of users to operate the system without constantly having to refer to other sources of information on the operation of the system. Human memory is classified into three separate categories, sensory, working (sometimes referred to a short-term), and long-term. Long term memory stores information for indefinite duration.

Sensory memory holds visual and auditory information for a duration of one to several seconds after which time it must be transferred to working or long-term memory or it will be lost. Sensory memory is equivalent to a temporary storage bin for information from the human sensory inputs. Sensory memory capacity can be demonstrated by the use of flash cards. The subject is shown a series of cards containing different information in rapid succession for short durations only. When asked to state what each card contained the success rate can be used to evaluate the short term memory of the subject.

Working memory is used to store information passed from sensory memory for short durations (up to thirty minutes). Working memory can be demonstrated by asking a person to remember a series of numbers and having that person repeat those numbers after several minutes. The success rate in remembering the sequence of numbers can be used to measure both the capacity and duration of the working memory.

Long-term memory is used to store information for later recall. Long term memory is used when studying for examinations or recalling how to get to and from an old friend's house. Studies have indicated that long term memory is more effective when information is stored in semantic categories (e.g., using simple mnemonics such as "bad boys ruin our young gardens" to remember the color bands, black,

brown, red orange, yellow, green, used to code electronics components). When studying for tests the act of reading and rereading information without semantically organizing the material is very inefficient [Sanders and McCormick, 1987, p. 63].

Systems interfaces must be designed to allow easy memorization of infrequently used or critical control information. Without this consideration the human will have difficulty determining the proper actions to take without reference to some outside information. This will slow the overall response of the human-system pair resulting in less than optimal performance of the system.

5. Human Information Processing Capabilities

Information theory is the collection and analysis of data related to the capability and capacity of information processed by the object being studied. Information is more than the raw presentation of collected data. According to Park:

> "Information is knowledge or news that reduces one's uncertainty or enhances probability of being correct about the true state of affairs. Receipt of information enables one to assign a higher (*a posteriori*) probability to a particular state that it had before (*a priori*) [Park, 1987, p. 17]."

Information must convey something of value to the receiver. Simply stating that the sun came up this morning is of no value as the person being told this data would have already known that - it is a given. If an event is about to occur and someone provides you with knowledge about the future outcome of the event, that knowledge is considered information. The measurement of information is quantified using a unit called the *bit*. An event with two possible outcomes provides one bit of information; a good example of this is a coin toss where the coin has the same probability of landing with either heads or tails up. Information is relative to the ratio of alternatives which are possible before the event to those possible after the event has occurred. This definition assumes that all outcomes are equally likely.

When performing calculations involving information, the notation H is used to represent the amount of information. The calculation of H for equally likely events is relatively simple:

$$H = \log_2 N$$

where H *= amount of information*
N *= number of equally likely events*

When the possible outcomes of the event are not equally likely the calculation becomes more complex. The

calculation must account for the different outcomes by using the probability of each event as follows:

$$H = \sum_{1}^{i} p_i \log \frac{1}{p_i}$$

Where H = *amount of information*
p_i = *probability of occurence of outcome* i

Information theory relates to uncertainty. The amount of uncertainty about what will occur in a given situation depends upon the number of possible outcomes and their probabilities of occurrence. As the probability of occurrence of a given outcome increases, the information provided by the occurrence of that outcome decreases. In other words, the amount of information in an event is inversely related to the probability that the event will occur. Applying the above rules to information theory it becomes clear that the situation where the largest amount of information would have to be processed is one where all possible outcomes have equally likely probabilities of occurrence.

6. How Information Theory Influences System Design

Information theory is used in systems development to determine the amount of information to be presented to the human using the system. When developing displays a general rule used for humans is to present "7 +/- 2" independent groups of information. This "magical number" comes from a study performed by performed in the 1960s by G. Miller [Park,

1987, p. 36]. Park points out that this number actually depends on the available stimulus dimensions; in geometric form identification 15 different forms can be readily identified which translates to 3.9 bits. [Park, 1987, p. 36]

The input commands necessary for systems under development must accommodate the limitations of human information processing and must not overload the humans using the system. This means that displays and indicators as well as the commands which have to be entered into a keyboard must not present such a problem as to confuse the operator. This is especially important when a user will conceivably use a system under time constraints or under mental stress.

B. BIOMETRICS

1. Definition

Biometric devices are devices which measure some physical characteristic of the human body or some repeatable action by the human. The major use of biometric devices is the identification or verification of humans wishing to gain access to some facility or application. Verification is the process of confirming that a person is who they claim to be. Verification requires the user to enter information in the system which "points" to that persons stored model. Identification is the process of determining the identity of

a person without any action required to pre-program the system.

Current biometric devices use hand geometry, fingerprints, blood vessel patterns in the eye, handwriting, and speech patterns to perform the tasks of verification and identification. The following section describes the basic principles underlying these systems. A series of laboratory experiments will be used to demonstrate the operation of these devices.

2. Description of Current Devices

a. *Retinal Scanners*

In 1935 Drs. Carleton Simon and Isodore Goldstein discovered that the pattern of blood vessels in a person's eyes are unique. In a follow up study in the mid 1950s, Dr. Paul Tower determined that the blood vessel patterns in identical twins were one of the most distinguishing features.[Eyedentify, 1987, p. 4]

Using this information, retinal scanners were developed which measure the pattern of the blood vessels in the eye [Figure 2]. This measurement is accomplished by measuring the amount of low-intensity infrared light reflected by the back of persons eye. The Eyedentification System scans

the eye in a 450 degree sweep and uses a phase correction process to account for rotation of the eye or head when the scan is taken. This information is then digitized and stored in a model which is stored in the device's permanent memory. The system then compares the patterns of a particular scan with the stored patterns to verify or identity of the person scanned. [Eyedentify, 1987]

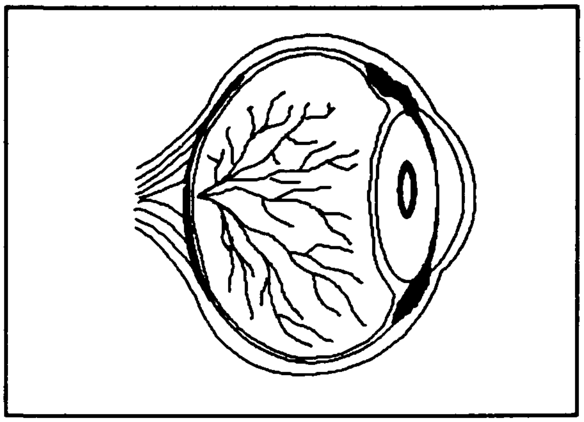

Figure 2 Blood Vessel Pattern in the Human Eye

The NPS WARLAB and SCIF both use the Eyedentification system in the verification mode. When students and staff desire access to these facilities they are registered by the security manager and given a personal identification number (PIN). In order to gain access to the facility the user simply enters the PIN and performs the scan.

The advantage to this method of entry is that the PIN is unclassified; release of this PIN will not allow anyone else to enter the facility. The major disadvantage to the identification mode is time related; as the number of personnel requiring access increases, the time required to search the database grows significantly.

b. *Fingerprint Devices*

Fingerprints have long been used by law enforcement and military organizations to perform the identification and verification function. The historical method of ink-and-paper recording of fingerprints required large volumes of storage and the sharing of this information required physical duplication.

The Identix Touchlock Personal Verification Terminals perform a three dimensional scan of the finger to determine the fingerprint patterns. This system scans the finger and stores a digitized sample of the fingerprint. Once this model has been stored it is used as a reference point to identify or verify a person. The Touchlock terminals provide some flexibility in the placement of the finger during the scan by using a reference point methodology. This methodology uses a set of reference points to set up the alignment of the stored model and the scanned fingerprint. [Identix, 1989]

c. *Hand Geometry*

Hand geometry systems began by measuring the two dimensional "shape" of the hand and comparing that with a database. When it became apparent this was not a unique measurement, the systems were improved to take three dimensional measurements of the hand. The Recognitions Systems ID-3D Hand Geometry system records a three dimensional

picture of the hand and stores unique characteristics of that pattern to verify a person's identity. The picture taken by a digital camera and 5 hand measurements are made to form the model. This model is stored in volatile memory for later comparison and verification purposes. An external memory device must be attached to allow permanent storage of the models. [Recognition Systems, 1986, p. 13]

d. Signature Verification

Signature verification systems began with the measurement of the pattern of the handwriting but forgery experts were able to gain unauthorized entry. The current systems measure the rhythm of the signature rather than the actual appearance providing a high degree of success in verification.

e. Comparison of Systems

The biometric devices mentioned in the previous section all have their advantages and disadvantages. In a study of the performance of biometric identification systems [Holmes, Maxwell, and Wright, 1990, p. 1] Holmes et al found that users favored a system which required them to carry a card to use the system. This is apparently due to the absence of any need to memorize special PINs and the perceived reduction in the time taken for entry.

The study also concluded that the general performance of biometric identification devices was insufficient to cause mass migration to these devices. The two systems which provided the most security were the fingerprint identification system and the retinal scanner. Neither of these systems allowed access by unauthorized users -- *false acceptance*. Advances in biometric devices should continue to increase their utility; these devices will provide easier, faster methods of controlling devices and entering information into these systems.

III. HUMAN FACTORS AND COMPUTERS

Computers are an ever increasing presence in the home and office. These computers bring with them a large number of human-computer interfaces, ranging from the standard keyboard and video display terminal to the optical pen and the flat screen display. Each of these devices must be designed for the acceptable performance or they will fall from favor with users. The following sections will describe current trends in computer input and output devices and will discuss some problems associated with these devices.

A computer provides the user with a large amount of capability provided the user can decode what the computer is presenting and also enter the proper commands to instruct the computer to perform the desired actions.

Early computers were programmed through a set of switches which were set in a certain way. The computer read the switches. The output from the computers was presented to the user through a set of lights on the front panel; in order to comprehend what the result of an operation was the user needed to decode the light sequence. This decoding of the information was a very tedious task and therefore large

amounts of information could not be presented to the user in a reasonable amount of time.

As technology progressed, input progressed through the following stages:

- Punched cards
- Paper tape
- Floppy disk
- Hard disk
- Optical disk

Output devices progress from the front panels lights through monochromic (two color) displays and then to low resolution color displays -- four colors in a 256 by 256 picture element (pixels) pattern for a 13 inch display. Technology now allows the presentation of 4096 colors in high resolution -- 1024 x 768 pixels on a 14 inch display. These advances in display technology have led to the development of another interface -- the graphical user interface (GUI) -- which has migrated applications from a text based display to one having all graphical elements. Information in GUI format is presented as a "picture" of the information called an icon. Icons allow the user to execute a set of instructions by simply selecting the icon. The theory behind the migration to the GUI environment is that the human-system interface becomes easier if the user does not have to know all of the technical

details of the computer operating system to perform complex operations.

A. User Input Devices

Keyboards are the most common form of computer input devices. The old standard for keyboards contained 56 keys and was modeled after the early typewriter keyboards. Modifications of the keyboards to adapt to the increasing needs of the computer have increased the number of keys on the standard keyboard to 101 with some newer models having over 135 keys. The additional keys are being added in an attempt to ease the use of the keyboard; additionally some keyboards allow programming of a set of function keys to perform a set of user defined keystrokes. Presumably these programmable keys allow the user to perform a more complicated set of functions with a single keystroke.

Additional work is being done in the research of keyboards with the newer keyboards tending away from the traditional key placement and towards more ergonomic arrangements. These new "keyboards" have been developed in an attempt to increase typing speed as well as reduce computer related injuries such as carpal tunnel syndrome. These new keyboards include single handed models which use "chords" --combinations of keys -- to produce commonly used groupings of characters. An early

attempt at increasing speed on keyboards was the Dvorak keyboard [Figure 3] which arranged keys according to their frequency of use. As the speed of computers increases and the size decreases more modifications will be made to increase productivity while reducing the "footprint" of the new input devices. [Kantowitz and Sorkin, 1983]

B. Graphical User Interfaces (GUIs)

Development of GUIs started with the XEROX workstation and continued with the Apple MacIntosh series of computers. These computers are based on the use of icons, pictures which represent the information being conveyed. An example of this is the "wastebasket" icon on the Macintosh computer systems. A more recent addition to the GUI environment is Microsoft Windows which was designed to provide users of MS-DOS based computers to operate in the GUI environment.

In order for a GUI to be effective it must be properly designed to convey the appropriate information and also to allow the user to interact with the computer in the easiest way possible. Several considerations which must be included in the design of the GUI are:

a) Design the GUI to allow for the clearest presentation of information possible.

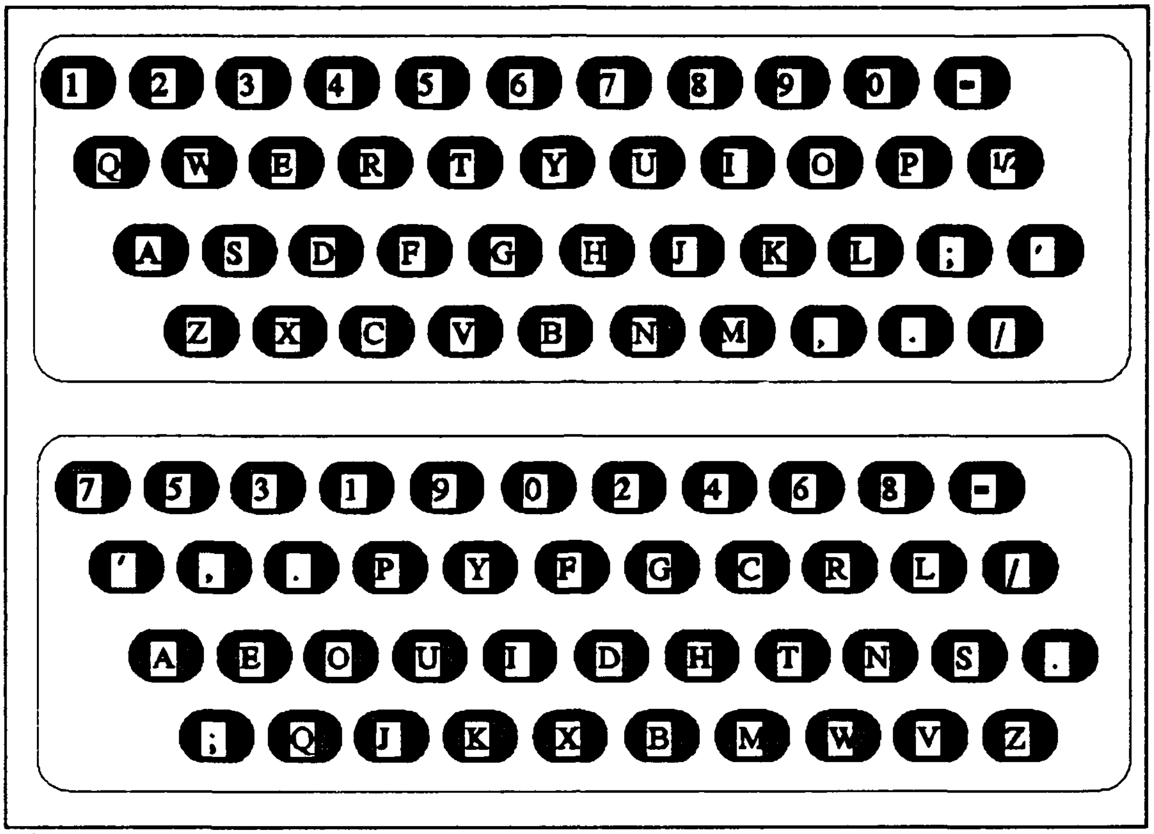

Figure 3 Comparison of Standard Keyboard (Top) and DVORAK Keyboard (Bottom)

b) Provide the user with an easy method to select the "current" application - e.g., simply moving the cursor into the appropriate window.

c) Clearly identify which of the windows is the "current" window. This can be done through the use of colors or by changing the background of the active window to highlight it.

d) Standardize the control keystrokes between different applications. The application of a standard like Common User Access[1] to application programs provides this standardization.

e) Provide a common message area for information which must be presented to the user and identify the source of the message. This is important even if the application is not the "current" application as some action may be required by the user to avoid failure of the specific application.

f) Provide an on-line help system. This is extremely important in a multi-tasking environment due to the easy confusion on how to accomplish something in different applications.

With the advent of GUIs, pointing devices have gained importance in the human-computer interface arena. These pointing devices include mice, trackballs, optical pens, and joysticks. These pointing devices allow the user to point at icons on the computer display which cause the computer program to jump to another function in that program or to execute another program altogether.

These devices become increasingly important when the computer is running in a multi-tasking environment where

[1] CUA is a set of standards defined by IBM to allow common keystrokes to be used to access similar functions in different software packages.

several applications programs (e.g., word processor, spreadsheet, and communications program) are all running simultaneously. The user can easily switch between which application is considered the current application by pointing to the "window" and "clicking" the pointer. This action is taken by pressing a physical button on the pointing device while the pointer is in the window for that application. The Apple Macintosh series of computers are well known for their graphical user interfaces. The ease of use of the Macintosh family of computers accounts for the large following of both computer literate and computer illiterate users.

C. Windows

The term "window" is used to refer to the area of a display device dedicated to a particular application or display entity. Windowing displays are used by a number of software packages to present relevant information to the user. Windowing of displays allows users to see output from a number of different applications or different portions of the same application on the screen simultaneously. This windowing of information is very useful on computers where a number of different applications can operate simultaneously.[Dunbar, 1990]

These multi-tasking systems allow the most efficient use of computer resources by sharing the processor in the computer. When one application is not using the processor the multi-tasking system seizes control of the microprocessor and passes that control to another application which is waiting to process some data.

The design of human computer interfaces is becoming increasingly important as computers are assigned more tasks of increasing complexity. The input devices and output devices for any automated system must consider the human using the system and the quantity and type of information being presented to the user. Additionally, the controls and indicators must be unambiguous; the meaning of every indicator must be clear and every control action must have a clearly identified result.

IV. COMPUTER NETWORKS

The transfer of large amounts of information between remote locations relied for years on the U.S. Postal service and other physical transportation devices involving human intervention. These services were reliable but generally took several days and even weeks to deliver parcels to other locations. The first data networks were developed in the late 1960s; researchers from Great Britain and the United States were among the first to recognize and capitalize on the advantages of computer networks. The initial efforts were motivated by the government but industry soon realized the potential these networks held for corporate and personal use. In 1967 the ARPANET became the first U.S. Government sponsored network, named after the Advanced Research Projects Agency (ARPA), now known as the Defense Advanced Research Projects Agency (DARPA).

Communications between computers in close proximity can be accomplished using direct connections between the two computers. When computers are not located near each other the establishment of a direct connection between each pair of computers becomes expensive and impractical. In order to reduce the cost of inter-computer communications, computer networks have been developed that allow connection between any

group of computers connected to these networks. The following section, strongly influenced by the work of Quarterman [Quarterman, 1990], will give a brief overview of computer networks.

A. Computer Networks

A computer network is a collection of two or more computers connected by a communications medium and capable of transferring data between the computers. Computer networks can cover areas as small as a single desk-top and can encompass an area as large as the world. The smallest network configuration is referred to as a local area network (LAN) which covers a very limited physical area. The largest network configuration is a wide area network (WAN) which covers hundreds or thousands of miles. A network which covers an area between a small local area and a large area, such as a group of buildings in different parts of the same city, is called a metropolitan area network (MAN).

Public Data Networks (PDNs), which are fee-for-service networks, were first implemented in 1976 were the Datapac network in Canada and the Telenet network in the United States. The number of PDNs has grown significantly since then and they now number in the hundreds around the world. Several

of the most well-known PDNs include Compuserve, Telenet, and Tymnet [Quarterman, 1990, p. 619].

Another category is cooperative networks; collections of participants willing to abide by the rules of the particular network and share the cost and resources required to operate the network. BITNET (Because-Its-Time-Network) is a worldwide cooperative network comprised mostly of educational institutions. Another popular cooperative network is USENET which is another worldwide network providing subscribers with only one service, distributed conferencing [Quarterman, 1990, p. 235].

When computers are connected to a dedicated network the computers can easily and reliably exchange information in continuous streams. However, when the computers are separated by a large distance the communications media can become less reliable and the capacity of the media decreases. There are two widely used methods of data transmission, *circuit switching* and *packet switching*. Circuit switched data transmission requires the dedication of a single communications path for the duration of the data exchange. This temporary communications path is called a virtual circuit. The most common application of circuit switching is for telephone networks where the information being transmitted is voice or digital signals converted to analog. While the

dedicated path allows for sequential transmission of data it also requires a certain amount of overhead to establish, maintain, and terminate the circuits. The single circuit also becomes a single point of failure in the data exchange; if the data link fails when the transmission is nearly complete, the transmission would have to be reaccomplished from the beginning.

In order to increase the reliability of bursty (i.e., greatly fluctuating amount) data transmission, another form of transmission called packet switching was developed in the late 1960s. Packet switched networks break each message into small chunks called packets and the packets are sent over the network separately. The size of a packet is dependent upon the network design but ranges between 1000 and several thousand bits [Stallings, 1991, p. 221]. Each packet is handled by the network as a separate message and these individual packets are reassembled into the original message. The routing and reassembly of the packets is handled by a device called a Packet Switched Node (PSN). The PSN performs a limited amount of error detection and correction and performs the store-and-forward function for each packet. Since the arrival of the packets may be out of order, the destination PSN must store the packets received until the final packet is received. At that time the PSN will

reassemble the message and forward it to the destination host.

This method of communications works well for digital data communications where the arrival of data at the receiving station is not time critical, but it is not generally acceptable for voice transmission. This is due to the possibility of non-sequential arrival of the packets at the destination which would render the voice unintelligible. A new method of packet switching technology, called Fast Packet Switching (FPS) has been developed which reduces the delay of the packets and standardizes the delay of each packet. This form of packet switching is being explored for use in the Integrated Service Digital Network (ISDN) and Broadband ISDN (B-ISDN) environments [Stallings, 1989, p. 105].

One of the largest packet-switched networks in the world is the Defense Data Network (DDN) which is comprised of the MILNET, Defense Integrated Secure Network (DISNET), Sensitive Compartmented Information Network (SCINET) and the Worldwide Military Command and Control System Intercomputer Communications Subsystem (WINCS). DDN is funded by the Department of Defense for military use. The DISNET, SCINET, and WINCS system are used for classified information processing while the MILNET is strictly for unclassified data.

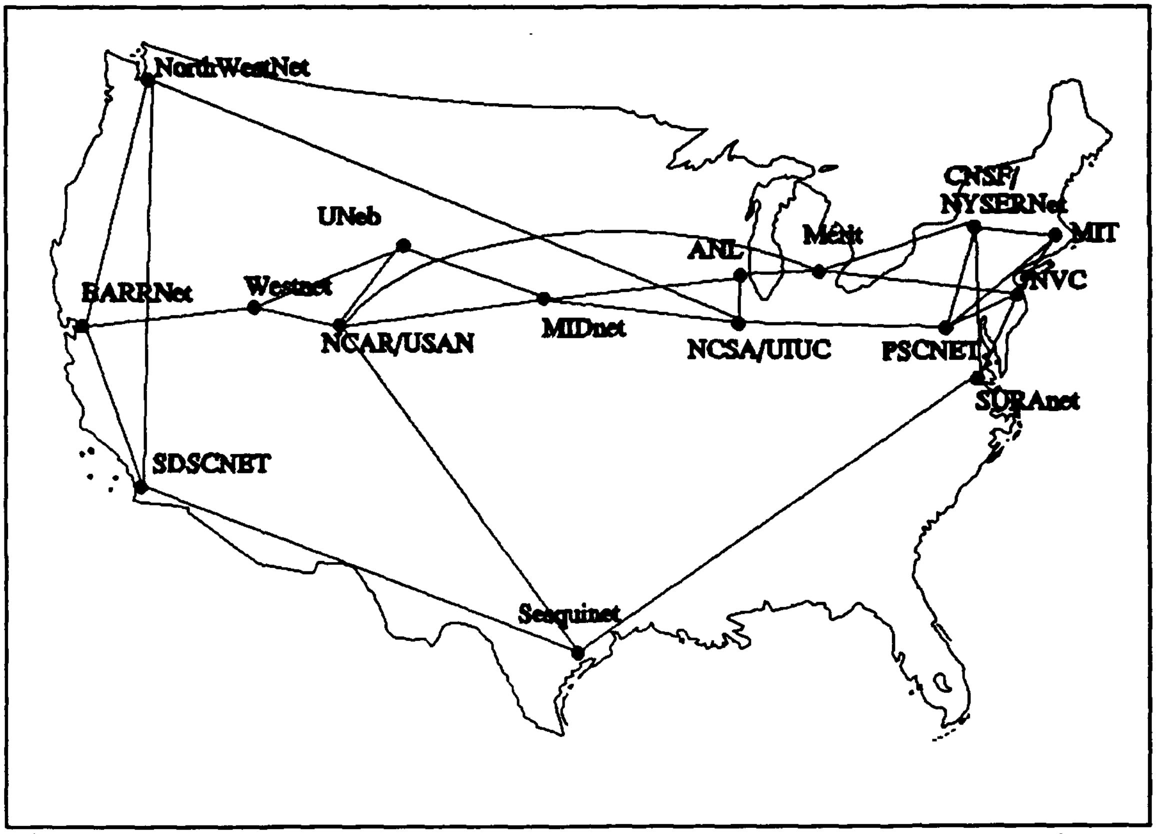

Figure 4 NSFNET Backbone (Adapted from Quarterman, 1990)

The MILNET is that part of DDN connected to a network of networks called the Internet. The Internet is a network of networks around the world connected through gateways[2] for rapid information exchange and sharing of resources by users at different locations. The Internet began in 1968 with the development of the ARPANET sponsored by the Defense Advanced Research Projects Agency as a proof of concept for long haul packet switched computer communications. The project was so

[2] A gateway is a specialized computer which serves as an interconnection between two networks using different protocol suites. This gateway acts as a converter between the different protocols of the networks connected to the gateway.

successful that its use for research grew rapidly during the 1970s and in the mid 1980s an unclassified military network named MILNET (Figure 5) was spawned with the sole purpose of supporting operational U.S. Military needs in data communications.

The ARPANET remained a research and development tool as it was originally used in the late 1960s and throughout the 1970s. It was retired in 1988 and 1989 due to the expense of maintaining it and its relative slowness compared with newer technology nets. Future U.S. Military network research needs will be met by the development of the Defense Research Internet (DRI) which will eventually handle all long haul computer communications for the U.S. Military community [Naval Postgraduate School, 1991, p. 7].

The ARPANET was fully decommissioned in 1990 due to the high cost of operation and slow speed of the network. The backbone of the Internet is now formed by the National Science Foundation Network (NSFNet) and MILNET with upwards of 400 networks connected to the Internet. NSFNet was established in 1988 as an interconnection between five National Science Foundation supercomputer centers. The interconnection between these backbone sites is via T1 leased circuits which allows data transmission at 1.544 Mbps. Figure 4 shows the current configuration of the NSFNet backbone. Besides the connection

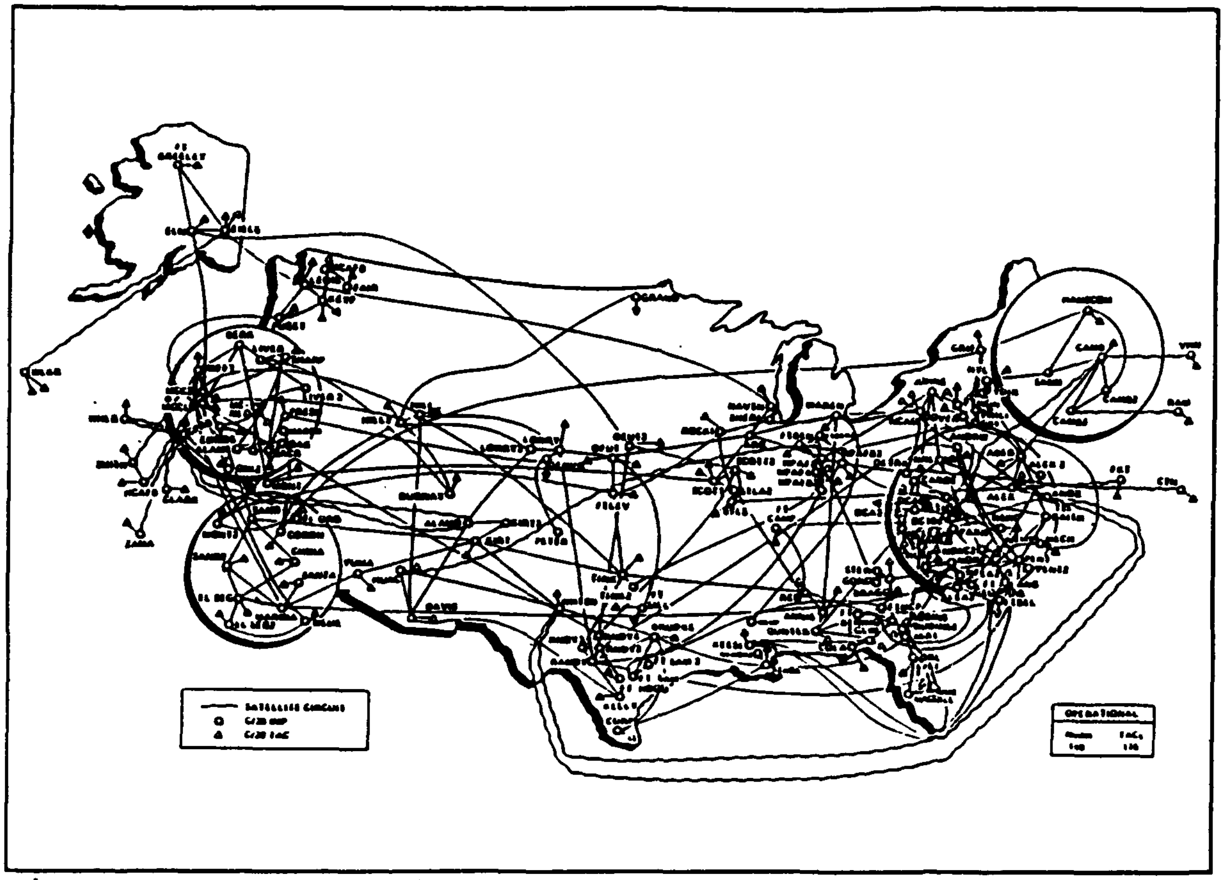

Figure 5 MILNET Backbone (Adapted from DDN New Users Guide, 1989)

of the supercomputers, there are many mid-level networks and over 200 institutions connected to NSFNet [Quarterman, 1990, p. 304]. One network connected to NSFNet is the Bay Area Regional Research Network (BARRNet) which serves as an internet for northern California and is based on full T1 circuits[3]. Organizations which are connected to the BARRNet include the University of California (UC) Santa Cruz, NASA Ames Research Center, UC Berkeley, US Davis, and the NPS W.R. Church Computing Center. When connecting to other facilities

[3] T1 refers to a standard for data transmission at 1.544 Mbps (U.S.) 2.048 Mbps (Europe).

on the Internet including DDN sites, NPS mainframe users may actually be using the BARRNet communications facilities.

In order for the computers attached to the Internet to communicate with each other they must be provided with the network address of remote host. The official network address for Internet hosts consists of four parts: the network number, the physical port number on the PSN, the logical port number, and the number of the PSN connected to the host.

The Internet Protocol addressing scheme is based on the class of service provided by the network. The following list provides the breakdown of the three most used classes in the Internet addressing scheme:

- Class A - Used for large, distributed networks with many hosts. Examples of class A networks are the MILNET. MILNET hosts are all identified by the number 26 in the first position of their network address (e.g., 26.120.254.50 is the host address for the NPS mainframe computer)

- Class B - Commonly used for networks which have subnetworks attached. This includes large universities and corporations having a number of LANs. (e.g., The Massachusetts Institute of Technology has a Class B network with the Address of 18.43.0.0. The MICHAEL.AI.MIT.EDU host is connected to a network with the address of 18.43.0.177)

- Class C - Commonly used for LANs directly connected to the Internet. (e.g., The Electronic Frontier Foundation has a LAN connected to the network which has the address 192.88.144.4)

NOTE: There are two additional classes of networks - Class D and Class E used for experimental and Internet specific purposes.

Data on host name-to-network address translation was initially stored in a file called the host table stored in each computer using the network to communicate. This method required every registered site to update their local copies of the database monthly to ensure the proper host address information resided on their host. The overhead associated with this process was significant due to the number of changes taking place in the network configuration.

A more efficient method has been developed to reduce the overhead associated with maintaining this single set of addresses by using a common naming convention. This method, called the Domain Name System (DNS), divides the internet into groups of users (*domains*) organized by functional activity or common interests. The following domains currently exist in the Internet [Naval Postgraduate School, 1991, p. 58]:

- COM - Commercial institutions
- EDU - Educational institutions
- GOV - Non-Military Government agencies and organizations
- MIL - Military agencies and organizations
- NET - Networking and backbone activities
- ORG - Not-for-profit organizations

Under the DNS, a host on the network is addressed by a logical name (i.e., CC.NPS.NAVY.MIL) instead of using a number (131.120.254.50); this eliminates the need for regular updates of the host address tables. The MILNET has not fully adopted the DNS method of addressing and some hosts must still be addressed using the host number.

Besides the above list of domains there is a national domain for the United States intended to include all hosts and sites that do fit into one of these six domains. Outside the United States there are many domains that are named by country of origin or "community of interest." Examples of hosts in these domains are WELL.SF.CA.US (Whole Earth Lectronic Link, San Francisco, California, United States), CSL.SONY.CO.JP (Computer Science Laboratory, Sony Corporation, Japan).

Access to the Internet can be accomplished through several different modes. The first method is for the user to access the network through a terminal connected to a host computer which is in turn connected to a PSN on the DDN. The user can then access files and applications programs on remote computers as though they were directly connected to the remote host; the limiting factor is the capacity of the Internet backbone. The data transmission capacities of the Internet are fixed; a large volume of traffic on the network will reduce the performance seen by all users.

DDN users have an additional method to access the Internet; through a Terminal Access Controller (TAC). Users can be directly connected to a TAC or access the TAC using a communications program on a personal computer and a modem. TACs are dedicated computers connected to PSNs; they provide terminals without local host access a method to connect to DDN hosts. TACs are located throughout the world providing access to the DDN and Internet.

In order to provide users with information about the network hosts and users, the Defense Information Systems Agency operates a service center accessible from computer connected to the network. This service center is called the DDN Network Information Center (NIC) and it currently provides the following services:

- User Assistance Hotline
- TACNEWS - information on DDN TACs
- Host Name Service - Phonebook of host names
- WHOIS - registry of DDN users
- NIC Query - file browsing for files stored on the DDN NIC
- Official DDN documentation storage and retrieval system
- Network Registration Services
- Security Coordination Center
- NIC Kermit Server - host server to allow Kermit download of documentation from NIC.

- **NIC Automated Mail Service** - service that automatically transmits requested documents to a user's e-mail account.

The NIC can be accessed through a TAC, TELNET, FTP, automated mail service, or directly through a dial-up phone modem. Additional information about accessing the NIC services can be found in the Defense Data Network New Users Guide [Naval Postgraduate School, 1991].

Additional service centers have been established by commercial organizations and network administrators to provide users with a single place to find information regarding hosts and users. One such service is the *KNOWBOT* system that resides on host NRI.RESTON.VA.US[4] which queries the DDN NIC, the Computer and Science Network (CSNET), and MCI Mail for the information requested. This service combines the information from the different databases and presents it in a common format [Malkin, 1991, p. 13].

The transfer of information over networks requires that the computers connected to the network all use the same data transmission formats or protocols. The following sections will discuss network protocols and the associated layer models.

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[4] This service is accessible using the command "**TELNET NIC.RESTON.VA.US 185**" which addresses port 185 on the host.

B. Computer Network Protocol Suites

The protocols used for computer networks are generally quite involved and as such have been organized in layers to separate the functions into manageable groups. These layers begin at the hardware oriented physical interface and progress upwards to those nearest the user, sometimes referred to as the applications layer. Communications between adjacent layers of the models are defined while communications between non-adjacent layers are not generally allowed. Two of the most common layering models used for data transmission are the Internet Reference Model and the International Standards Organization (ISO) Open Systems Interface (OSI) model [Quarterman, 1990, p. 46].

1. Internet Reference Model

In the mid 1970s and early 1980s ARPA sponsored a project to develop a protocol suite for use by DoD agencies. The primary impetus for developing this protocol suite was the reliable transmission of data after damage occurred to the network carrying the data. This protocol suite was primarily intended for use on the ARPANET packet switched network.

The DoD adopted this protocol suite and issued a set of standards which define the characteristics of the protocols

to be used for military data communications. While there is no formal name for this set of protocols it is commonly called the DoD TCP/IP suite. The reference comes from the use of two protocols: the Transmission Control Protocol (TCP) which is a stream protocol and the Internet Protocol (IP) that is an unreliable datagram protocol. Stream protocols allow the transmission of large amounts of information in a continuous stream. IP datagrams break the information into a series of packets and each of these packets is routed through the network as an independent message. When each packet reaches a node in the communications path, the control equipment must make a decision regarding the routing of that message. The IP datagram system is not extremely reliable and as such additional protocols have been developed to increase the reliability. The Internet model is based on the three layer (network, transport, and process) ARPANET Reference Model but adds a fourth layer, the internet layer which handles communications between networks. The following section will describe the development of the open systems model currently being pursued by the International Standards Organization and the Department of Defense.

2. ISO Open Systems Interconnect Model

In 1977 the International Standards Organization (ISO) recognized the need to develop a set of standards that allowed for communication between computers manufactured by different vendors and running different operating systems and applications. The ISO developed the Open Systems Interconnect (OSI) model that establish a set of standards for communications between different computers. This model is not a specification for the development of computers but is a building block developed to allow further specification of standards at different levels [Stallings, 1991, p. 447].

The ISO-OSI model uses seven layers, with each layer performing a limited set of functions that allow the system to communicate with another system. The layers are arranged in order of complexity with Layer 1 being the least complex while Layer 7 is the most complex. The layers of the ISO-OSI reference model are as follows [Stallings, 1991]

1) Physical Layer: Defines the mechanical, electrical, functional, and procedural characteristics of the physical interface between devices.

2) Data Link Layer: Provides error detection and control and provides means to activate, maintain, and deactivate the link between devices. This layer handles synchronization, error control, and flow control.

3) Network Layer: Provides transparent transfer of data for all layers above Network layer. Responsible for establishing, maintaining, and terminating *connections*.

4) Transport Layer: Ensures error free, sequential data delivery. Responsible for end-to-end recovery and flow control.

5) Session Layer: Provides for establishment and operation of sessions between two application processes. This layer has mechanisms that allow for recovery if transmission errors occur.

6) Presentation Layer: Defines the syntax of data transmitted between applications processes. Encryption of data is performed at this level.

7) Application Layer: Provides method for applications to access the OSI environment.

The first three layers of the OSI standard are concerned with the communications details of the networks while Layers 5 through 7 are concerned with the user applications. Layer 4 provides a means for applications at Layers 5 through 7 to access the network communications facility provided by Layers 1 through 3.

3. GOSIP

The U.S. Government has adopted a set of standards that comply with the ISO-OSI reference model standards. This was done to allow exchange of data and information between organizations, both private sector and Government, relatively easily and inexpensively. This set of standards is called the Government Open Systems Interconnection Profile (GOSIP) and is based on agreements reached at the National Institute for Standards and Technology (NIST) Workshop for Implementors of

Open Systems Interconnection [GPO, 1990, p. 1]. This profile has been mandated for all Government agencies purchasing systems network systems. Whenever an agency procures a system for network use it must be GOSIP compliant in addition to the basic performance specifications identified by the procuring agency. GOSIP Version 2 allows for the following services:

- Electronic mail
- File transfer
- Virtual Terminal Service (TELNET and Forms profiles)
- Office Document Architecture
- Integrated Services Digital Network (ISDN)
- End System-Intermediate System (ES-IS)

and, as user options;

- Connectionless Transport Service (CLTS)
- Connection-Oriented Network Service (CONS)

The protocols mentioned above are those used when permanent connections are established. Additional protocols have been developed for communications paths that are not permanent and therefore subject to changing error rates and transmission speeds. There are too many of these protocols to discuss each in this thesis so only the most frequently used will be discussed. The protocol suites of interest to this thesis are Kermit, Xmodem, Ymodem, and the associated Zmodem.

4. Kermit

Kermit is a file transfer protocol originally developed at Columbia University in 1981 in an effort to allow data exchange between several different types of computers. This protocol is a half-duplex[5] error correcting protocol modeled after the FTP file transfer protocol and the TELNET remote login protocol. This protocol provides transmission of both binary and text files between hosts operating under different software environments. There are currently hundreds of different implementations of the Kermit protocol, each developed for different operating environments or increasing the capabilities of other versions. These public domain versions of Kermit software are available via anonymous FTP from host WATSUN.CC.COLUMBIA.EDU at the Columbia University Center for Computing Activities.

In most implementations of Kermit, one of the computers is placed in "server mode" and the other is in "local mode" meaning that one computer is a slave to the other computer in the communications session. This allows users to enter commands only at the local terminal for file transfers as opposed to having to enter commands at both the local and

[5] Half-duplex transmission allows the transmission of data in only one direction at any given time. Full-duplex transmission allows data flow in both directions at any given time.

remote computers. Any commands that are entered are negotiated between the two computers and the file transfer takes place. Kermit also allows transmission of multiple files without creation of a session for each file transfer. Although the files are all sent during the same session, they will each be sent as a separate entity encapsulated by error detection and correction information. While Kermit is a slow transfer protocol, the portability of the software and the continued improvement has ensured that Kermit will continue to be used worldwide [Quarterman, 1990, p. 57].

5. Xmodem and Its Variants

Xmodem is a nickname coined for the Christensen protocol developed in 1977 by Ward Christensen. Originally designed for use on CP/M machines this protocol has spawned many related protocols including Ymodem, Zmodem, Wmodem, Modem7, and Xmodem-CRC. The basic Xmodem protocol is an error detecting and correcting protocol that uses 8 bit bytes to transfer both text and binary data; no distinction is made between the two. Xmodem does not allow controlling data flow between the modem and the computer due to the possibility of control characters occurring within the data.

The Xmodem protocol ensures that packets are properly ordered at the destination station; duplicate packets are

simply ignored and not relayed to the destination station. Text files and binary files in the treated the same by the Xmodem protocol. The data transmission rate of Xmodem is twice that of the Kermit protocol when transmitting binary files but the two are nearly equal when transmitting ASCII formatted files due in part to the use of 8-bit bytes by Xmodem.

Ymodem improves on the basic "as-is" transmission style of the Xmodem protocol by sending the filenames, size, and creation date of the file during the initialization of the communications link. In addition to these advances the Ymodem protocol sends information in blocks of 1000 bytes as opposed to the 128 byte blocks of Xmodem. This enhancement alone increases the efficiency of the protocol up to 60 percent over Xmodem. Another benefit to the Ymodem protocol is that it can send files in batch mode which reduces the amount of user interaction required when several files are being transmitted.

Zmodem also allows batch transfer of files and in addition achieves near 98 percent efficiency. This is done through the use of checkpoints and windows -- the insertion of error correction information into the file at intervals. When an error occurs the receiving computer notifies the sending computer to set aside the error-containing code and retransmit it later. One additional feature that made Zmodem a favorite

for large file transfers is the ability to resume a file transfer that was previously interrupted -- file recovery.

A common method of increasing the speed of file transfer is the compression of the file at the transmitting end and the decompression of this file by the receiving station. This compression/decompression can either be done by the modem as the file is being transferred or it can take place off-line before and after the file transfer. The advantage to compression off-line is that the size of the file can be reduced by up to as much as 3/4 of its original size. The disadvantage is that this process takes both disk space and time. On-the-fly compression/decompression is performed by hardware and software packages in newer modem technologies. This technique can essentially quadruple the advertised speed of the modem being used.

A major drawback of file transfer protocols is that they do not perform their error correction during normal modem operations (e.g., instructing the remote computer what files to transfer). In response to this problem standards were developed which include full-time error correction; these standards are automatic request for repeat (ARQ), Microcom Networking Protocol (MNP), and CCITT V.42. These standards all have hardware embedded error correction algorithms which

allow for transmission of data at speeds of 9600 bps and greater.

The ARQ error correction method is to have the receiving modem immediately request retransmission of erred data. The MNP set of protocols allow varying levels of error correction; several allow for file compression to further increase the data transmission speed. The V.42 standard employs additional techniques to allow faster and more error-free transmission of information. MNP is becoming a defacto standard in many commercial access networks such as Compuserve, GEnie, and MCI Mail while V.42 is gaining popularity [Dvorak, 1990, p. 486].

C. Computer Mediated Communications

Computers provide significant capabilities in the communications arena. They allow users to transfer information to other locations in machine readable form to allow humans and computers at the remote locations to access and modify that information. Computer communications can be carried out in several ways: one-to-one, one-to-many, and many-to-many. The following paragraphs will discuss each of these in more detail.

1. One-to-One Communications

A significant capability provided by computer networks is the exchange of information between different users. This capability is most commonly called electronic mail (e-mail) and can be conducted either in detached mode or interactive mode. The detached mode is commonly called batch mode and simply means that the users do not both have to be logged on to their respective host computers to carry on a conversation. The messages are sent from the originator's host to the recipient's host and stored until the recipient logs into their account and reads the mail. The advantages of these systems become apparent when access to the telephone is difficult. These systems eliminate the need for "telephone tag" that can become extremely frustrating when there is a significant difference in the time zones or the work schedules of the individuals involved.

Another form of one-to-one communications system allows users to converse in near-real-time over computer networks. These systems operate in what is known as interactive mode; one user responds to messages from the other user when that message is posted on the system. This communication can take place between two users on the same host (e.g., the *tell* command on the NPS mainframe) or between two users logged on to a different host (e.g., the *chat* command available on many bulletin board systems and the *tell*

command on BITNET). These interactive systems are quite useful when two users are logged onto their respective systems and need to pass a short amount of information back and forth.

2. One-to-Many Communications

There are several ways for computer users to transfer information between a single user and many other users; the most common of these being "bulletin board" systems (BBS), mailing lists, and automated mail systems.

a. *Bulletin Boards*

Bulletin boards are a form of one-to-many communications where a single computer has remote access ports (either modems or network connections) and the users log on to the system individually. Once the user has logged on to the system they may transfer information from the BBS to their system (called downloading) and the user may transfer information from their system to the BBS (called uploading). Additionally, users may have access to an e-mail system to leave messages for the system operator or other users.

While the most commonly known use of bulletin boards is for entertainment purposes, the military has developed several bulletin board systems for use by military personnel. These are repositories of information where

military personnel can access previously developed software programs or information that is DoD owned and download that information for use on their local computer.

The Navy and the Air Force have both developed bulletin board systems that allow military personnel to get current information regarding the available billets. The Air Force System, which resides on a host computer at Randolph Air Force Base in Texas, contains a number of categories of jobs and specialty assignments. These categories include both rated (aeronautical) and non-rated positions and are further divided into Air Force Specialty Codes. The Navy has an equivalent system (BUPERS) that allows Navy officers to communicate with their detailers in Washington DC. This system provides an opportunity to communicate with their detailer using electronic mail messages.

One system of special interest to Naval Postgraduate School students is the Closet Gouge BBS. This BBS contains hosts discussion groups on different subjects such as MS-DOS based computers, Macintosh Computers, Windows 3.0, Amiga Computers, PC-SIG CD-ROM and more. This bulletin board was developed in an attempt to provide NPS students with an alternative means to share information regarding courses and items of interest to NPS students. The BBS also contains private conferences that allow students to join and share

information only with other members of the same conference. As the need has grown this BBS has merged with the NPS Computer Club BBS and consists of two computers connected on a LAN.

One additional bulletin board that may be of interest to military officers include the NCTAMSLANT Bulletin Board System which contain U.S. Navy specific software. This BBS is a private system and users must register before gaining access[6] to certain areas of the BBS. This system contains database management, word processing, communications, spreadsheets, bar coding, and system utilities software. Both MS-DOS and Macintosh software is available on this system.

b. Mailing Lists

Mailing lists are computer maintained lists of e-mail addresses providing a means for easy distribution of information between users. These mailing lists may be for accounts on the same host (e.g., the mailing list an NPS professor uses to send homework assignments to students) or can be lists of Internet users around the world. These mailing lists are generally used to send textual information to groups of people who have expressed an interest in the

[6] The NCTAMS LANT BBS phone number is commercial (804)455-1121, DSN 565-1121. This BBS can be accessed by civil service and military personnel.

particular subject identified for that mailing list. A common example of this is the use of DDN mailing lists to announce upcoming conferences and working groups on systems such as the WWMCCS ADP Modernization program. These mailing lists have been used to transmit documents that are over 150 pages in length for review and comment. This method of providing the information both reduces the turn-around time for the document and reduces the delivery costs for bulky documents.

c. *Automated Mail Service*

An automated mail service is a service designed to provide access to computer information to users who would otherwise not have access. Users with no access to the file transfer methods discussed in the following section can use automated mail services to get information from remote locations. A user initiates the automated mail service by sending an e-mail message to the host with the name of the desired file contained either in the *Subject* line or the text of the message. When the remote host gets this e-mail message it in turn "reads" the name of the desired file and the e-mail address of the requesting user. The host then sends the file as an e-mail message addressed to the user. Although not all hosts provide this service it is available on services such as the NNSC, the NIC and a number of educational institution computers.

3. Many-to-Many Communications

There are several ways for multiple users to communicate over computer networks. These include teleconferencing systems, multi-user simulation environments (MUSEs), and multiple user dungeons (MUDs).

a. Teleconferencing Systems

Teleconferencing systems are similar to conference calls for computer networks, allowing many users to join the conference and carry on a discussion; all users able to see what every other user is saying unless specific commands allow limited communications modes. These systems are very similar to telephone conference calls in that the mediation of conversation must be carefully controlled to avoid confusion. One military application of teleconferencing is the Worldwide Military Command and Control System (WWMCCS) Teleconference (TLCF). TLCF allows personnel involved in the deliberate planning of military operations to exchange information regarding equipment and personnel status.

b. Internet Relay Chat

The Internet Relay Chat (IRC) system is a multi-user conversational system where users converse over "channels." IRC channels are organized by topics that may be anything from general conversation to discussion regarding a

particular event. This method of communications gained notoriety during Operation Desert Shield and Operation Desert Storm when an IRC conference was established solely for discussing these operations. Frequently information regarding the operations was available on this conference before it was available to the public through news media channels. The IRC was developed as an alternative to the "talk" and "phone" programs that allow only two users to be connected at a given time. Additional information regarding the IRC is available via anonymous FTP from Internet host FTP.EFF.ORG in the IRC subdirectory; the files TUTORIAL.1, TUTORIAL.2, and TUTORIAL.3 contain information regarding IRC policies and procedures.

c. MUSEs and MUDs

MUSEs and MUDs are multi-user programs simulating different environments accessible through computer networks. These systems allow creation of totally imaginary environments and objects that take on their own characteristics. These environments can be cities[7], a matrix of caves, or a galaxy of planets containing many locations to visit. The MicroMuse MUD hosted at MIT is conceptually designed around a cylindrical space station that is composed of sectors and rings. Areas of

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[7] The MIT MUSE named MicroMuse resides on Internet host MICHAEL.AI.MIT.EDU. Users can log on as *guest* and can request permanent access to the system via e-mail to the following account: *micromuse-registration@chezmoto.ai.mit.edu*.

the space station that are currently available include a library, shopping center, science lab, rain forest and hotel. Additionally, users can develop "spaceships" that allow players to leave the space station and wander around in CyberSpace.

These examples are of "games" to be played on the computer networks but these systems can be put to use in the military environment. For example, the Worldwide Military Command and Control System contains a teleconferencing facility that supported and supporting commands can use in the deliberate planning (as opposed to crisis action planning) phase of military operations. These teleconferences allow near real time resolution of issues instead of relying on the already burdened automatic digital network messaging systems to transfer that information. These systems also allow users in several different locations to conduct business while avoiding time consuming travel. While teleconferencing systems cannot replace all face-to-face meetings, they can reduce the number and frequency of these meetings.

D. Computer Resource Sharing

Computer networks and multi-tasking systems allow several users to share both hardware and software systems; this sharing reduces the need for everyone to have an entire set of

hardware and software at their location. This is especially important when the user only infrequently accesses the capabilities and therefore the cost of the system cannot be justified for a single user. One of the most important capabilities provided is the sharing of supercomputers. NSFNet is designed to accommodate the sharing of data and resources between many supercomputing centers over a high speed data network. NSFNet also allows research and education organizations to access supercomputing resources that otherwise would be unavailable to them. THE NSF Network Service Center (NNSC.NSF.NET) and the DDN Network Information Center (NIC.DDN.MIL) are two previously discussed examples of resource sharing.

1. Time Sharing Systems

One example of computer resource sharing that is very applicable to NPS students is the time sharing system on NPS mainframe. Time sharing systems allow multiple users to access the same computer or a shared basis, each user only gets a fraction of the total available processing power. The NPS mainframe contains many applications programs that the students can access simply by having a user account on the mainframe. These applications include: STATGRAPH (a statistical analysis package), MINITAB (statistical package), XEDIT (text editor), TELNET (telecommunications program), FTP

(file transfer program), the KERMIT system and others. The cost for each of these programs is significant and having these software packages on the mainframe allows NPS students to use them while they are enrolled at the school. Additionally, hardware devices, such as the line printers and disk drives, allows students to access costly peripherals they otherwise would not be able to use.

2. The TELNET Protocol

The Telecommunications Network (TELNET) protocol system allows users to log on to remote hosts and access any of the applications programs they have access to with their user id and password. Commonly called remote login, this sharing of resources can increase productivity of personnel by reducing the delay times associated with travel to and from the host computer. TELNET also can reduce the number of copies of a given package that must be purchased by allowing personnel to have temporary access to programs that they need on a one-time basis without having to purchase copies of these programs. Both options allow for a significant cost savings in the purchase of both hardware and software. While access over a network can sometimes be slow, especially when the network is congested with users, the advantages of using these options must be weighed against the relative costs when developing new systems.

3. File Transfer Protocol

File Transfer Protocol (FTP) is an implementation of a protocol suite that allows users to connect two mainframe computers in a network and transfer files between the hosts at high rates of speed. FTP generally requires the user to have access to user accounts on both computers in order to have access to files. An exception to this is the use of the *Anonymous* accounts established on many computers in the Internet. Anonymous accounts are given limited access to certain files on the host computer allowing users to transfer these files to their own host computers. Once these files are transferred to the users host they can either be accessed directly on that host or they can be transferred to the user's personal computer using one of the previously described protocols.

The number of services and sources of information available on the Internet is too extensive to discuss in any detail in this thesis. For additional lists of the Internet FTP sites users can TELNET to the Archie Server (QUICHE.CS.MCGILL.CA) and access a database containing this information. Additional information regarding the history and future of MUSEs and MUDs can be obtained by FTP from host MICHAEL.AI.MIT.EDU located at MIT in Cambridge Massachusetts.

V. SUMMARY

The human-systems interface is a much overlooked part of systems being developed today; it is at the same time become increasingly important. The development of highly complex computer controls and displays requires careful thought and a great deal of research. This thesis introduced the concepts used to develop the human-systems interface; it has not attempted to develop a complete reference for the student, but more a starting point for further research.

This thesis also introduced a limited subset of the capabilities of the matrix [Quarterman, 1990] of networks -- called the Internet -- *which exists in the world today. Using* the information introduced in this thesis, the reader should begin to understand the utility of the Internet. Additional information is made available on the network daily, any publication which attempts to keep pace with the changes is outdated prior to going to press. The most useful method to keep abreast of changes in the world of networks is through daily exposure to the networks.

APPENDIX A - LABORATORY EXERCISES

A. AN INTRO TO USING THE NPS MAINFRAME

1. Exercise Description

Before you can access the NPS mainframe computer you must get an account from the W.R. Church Computer Center staff. The Computer Center is located on the first floor of Ingersoll Hall. When you establish your account the computer center staff will also give you several manuals which describe the mainframe operating system and the commands you will use to control your mainframe account. If you have an MS DOS based personal computer with a modem you can get a copy of the communications package SIMPC Version 6.0. This package allows you to access the mainframe by emulating an IBM 3279 terminal and using the function keys on your personal computer to perform specific actions. This set of exercises will assume that you have access to the NPS mainframe computer, either through one of the many hardwired terminals located around the school or through a modem and the SIMPC program. Throughout these exercises the reference to "Fx" where x is a number refers to functions keys on a PC running SIMPC while "PFx" will refer to the PF keys on a 3278 terminal.

These exercises will introduce the student to several different message communications capabilities on the NPS mainframe computer which will be used throughout the course. The student will learn basic commands *for* the *NAMES*, *NOTE*, BITLINK MAIL, and SENDFILE facilities. For further information regarding the NPS mainframe procedures refer to the NPS Handbook *Introduction to the W.R. Church Computer Center* available from the computer center [Naval Postgraduate School, 1991].

2. Exercise Instructions

a. Using PUBDIR to Determine USERID numbers

(1) Log on to the mainframe using your own account and password.

(2) To identify the account number of the person you wish to send mail to type *PUBDIR* at the operating system prompt.

(3) Type *L /name* where *name* is the last name of the person whose account number you need.

(4) To access another person on the list first enter the command *top* which moves the pointer to the top of the names list.

(5) Press the "PF3" or "F3" key to exit the system once you have located the account number.

b. *Using the NAMES Utility to Manage Nicknames*

(1) You may now enter the nickname and USERID number into your nickname file by typing ***NAMES*** at the prompt.

(2) You must fill in the NICKNAME and USERID blocks but the rest of the information may be left blank.

(3) When the entry is correct press the "PF2" or "F2" key to add the nickname to your list.

(4) Press "F3" to exit the names system.

(5) You may now use the nickname entered in the names file wherever the system requests USERID.

c. *Using NOTE to Send Messages to Other Users*

(1) To send a short note to someone you simply enter ***NOTE name*** where name is the USERID or nickname.

(2) Enter *INPUT* and begin typing the text of the note.

(3) Press the "PF5" or "F5" key to send the note.

(4) Press the "F3" key to exit the NOTE system.

d. Using the BITLINK MAIL Facility to Send Messages

(1) Enter **BITLINK** at the system prompt and then enter the password when prompted.

(2) Type ***SEND*** at the system prompt and enter either the nickname or the userid of the intended recipient of the message.

(3) Enter your name and the subject of the message when prompted.

(4) Use the TAB key to position the cursor in the area below the header information and above ****END OF DOCUMENT****. This is the message area.

(5) Type the message using the TAB and BACKTAB keys to move between the lines of the message. Press the "F2" key to add more lines if necessary.

(6) Press the "F5" key when ready to send the message and again when prompted to "enter SEND again to send message."

(7) Press the "F3" key to exit the mail system and then enter ***BITDROP*** to return to the operating system.

e. ***Sending a File to Another User using SENDFILE***

(1) Enter ***SENDFILE username filename filemode filetype*** at the operating system prompt. Username can either be the userid or the nickname from your names file.

(2) The file will be logged into the receiver's RDRLIST.

(3) To retrieve a file from your RDRLIST type **RDRLIST** or RL at the system prompt. The system will then display all files in your reader.

(4) TAB to the file you wish to receive and press "PF9" or "F9" to receive the file. It will now be stored in your file directory.

(5) Press "PF3" to exit the RDRLIST. You may now examine the file using the Filelist View feature by typing **FILEL**, moving the cursor to the appropriate file and pressing "PF10".

B. USING A TERMINAL ACCESS CONTROLLER

1. Exercise Description

This exercise will provide the student with the tools necessary to access the DDN using a Terminal Access Controller (TAC). The student will learn the basic command sets used for

controlling the speed of the TAC and opening and closing connections with hosts on the DDN and Internet. Table II provides a subset of the commands available for use on the TAC; these commands can be entered at any time after connection to the TAC is established. [Defense Communications Agency, 1987]

2. Exercise Instructions

a. Start the communications program and dial the local terminal access control number. For NPS students the local TAC number is 647-8422.

b. "Wake-up" the TAC by pressing the **<Ctrl>** and **<Q>** keys simultaneously. If using a 9600 bps modem use **<CTRL><A>** in place of <CTRL><Q>. When the TAC recognizes the "wake-up" message it will send the TAC herald -- the opening announcement for the TAC.

c. A connection may be opened to a host by typing **@o** ***address*** where *address* is the numeric Internet address of the remote host. The TAC will then prompt for TACID and Access Code.

d. After logging off the host computer close the connection between the host and the TAC by typing **@c** and log off the TAC by typing **@l**.

TABLE II Subset of TAC Commands (Adapted from TAC User's Guide)

@B I S	sets TAC to binary input mode
@B I E	terminates binary input mode
@B O S	sets TAC to binary output mode
@B O E	terminates binary output mode
@C	attempt to close connection
@R	resets connection releases port resets binary modes redisplays the TAC herald
@L	logout from TAC
@N	connect to DDN NIC
@O *address*	Open a connection
@R I C	resets initial TAC conditions

3. Questions for the Student

a. What is the command used to "wake up" the TAC?

b. What is the TAC herald?

c. What command resets the TAC?

d. How is the @R command different from the @L command?

e. What does the @N command do?

f. What commands set the TAC to binary mode?

g. What commands terminate the binary mode?

C. THE DDN NETWORK INFORMATION CENTER

1. Exercise Description

This experiment will provide a basis for the student to locate information regarding the Domain Name Server (DNS) names of host computers on the Internet. The student will log into the Network Information Center (NIC) host computer and gather information regarding the services provided by the NIC. The student will then use the NIC to find specific information regarding specific network hosts and users.

2. Exercise Instructions

a. For TELNET connection open a connection to the NIC using host address NIC.DDN.MIL.

b. For TAC access type **@N <ret>** at the TAC prompt. Enter the proper TAC Userid and Access Code when prompted.

c. Once logged into the TAC type ?. This provides a list of the available services.

d. Type **TACNEWS** to get the latest information regarding TACs on the DDN.

e. Type **WHOIS** to find the network address and host information for users on the DDN.

f. Type **HOST** to determine information regarding hosts on the DDN.

3. Questions for the Student

a. What commands are available when you first enter the NIC?

b. What does the WHOIS command provide?

c. What addresses are listed for NPS mainframe computers?

d. Where is the NIC hosted?

e. What operating system is the NIC using?

f. What is TACNEWS?

g. How many servers are there in the EDU domain?

h. How many hosts are there at Langley Air Force Base and what are their addresses?

i. What is the host name at NARDAC?

j. What general categories of documents are available from the NIC?

D. THE KERMIT FILE TRANSFER PROTOCOL

1. Exercise Description

This exercise will take the student through the use of the Kermit file transfer protocol to transfer files between the mainframe computer and the local personal computer. Before this exercise can performed the Kermit communications package must be loaded onto a personal computer with a modem.

The compressed file, MSVIBM.ZIP which contains executable files for use on an MS DOS computer is available

via FTP from host WATSUN.COLUMBIA.EDU on the Internet. These files must be extracted from the compressed file using the PKUNZIP utility program. The files which are included in MSVIBM.ZIP for Kermit Version 3.11 include;

ANNOUNCE.TXT:	Announcement containing information about the files contained in MSVIBM.ZIP.
DIALUPS.TXT:	Text file containing numbers and settings to use with Kermit DIAL command.
HAYES.SCR:	Initialization file to allow Kermit to recognize Hayes Compatible modems.
KERMIT.BWR:	Warning file containing information about known bugs and shortcomings in Kermit.
KERMIT.EXE:	Executable file.
KERMIT.HLP:	Help file describing keystrokes and commands.
MSKERMIT.INI:	Initialization file for Kermit.
MSKERMIT.PCH:	Patches which fix some known bugs and shortcomings.
READ.ME:	Text file containing information about Kermit

MacIntosh users can obtain the MacKermit program by downloading the file CKMKER.HQX from WATSUN.COLUMBIA.EDU. This file is in BinHex format and must be converted into the executable files using BinHex version 4. MacKermit Version will run on all MacIntosh computers except the original 128K Macintosh and the MacIntosh Classic. Additional files available from the Kermit Server include the following:

CKMKER.DOC:	ASCII text version of MacKermit Users Guide

CKMKER.MSW:	Microsoft Word version of MacKermit Users guide - in BinHex format
CKMKER.BWR:	A "beware" file documenting the known problems with MacKermit
CKMKER.HQX:	MacKermit Program Version 0.9 in BinHex format.
CKMKER.SET:	A settings file for the Mac SE in BinHex format

The Kermit program is essentially two programs in one, a terminal emulation program and a file transfer program. The MS DOS version of Kermit must be configured to recognize the modem which is connected to the PC before a connection can be made. The KERMIT.HLP file contains information regarding the commands used to configure the modem properly.

The following set of instructions is for MS DOS computers, MacKermit commands differ and are further described in the MacKermit Users Guide.

Once the modem is configured, the communications portion of the program can be initiated by the **CONNECT** command and the modem can be instructed to dial the desired remote computer. Logon and setup of the remote computer is done using the communications portion of the Kermit program. Once logon is complete the user "escapes" back to the Kermit portion and performs the desired file transfers. The instructions for

using the Kermit terminal emulation and the file transfer are detailed in the text files mentioned above[8].[da Cruz, 1987]

2. Exercise Instructions

NOTE: These instructions are for MS DOS computers, MacKermit users please refer to the MacKermit Users Guide.

a. Load the Kermit program by typing **kermit** at the DOS prompt. Ensure the data rate, modem port, and terminal type are set properly for this session. Use the **set speed xxxx**, **set port x**, and **set terminal yyyyyy** commands. In these examples x represents a number and y represents an alphanumeric character. To determine what commands are available type **?** and a list of commands will be displayed. To determine the syntax and options for a command type **command ?** where command is one of the valid commands listed using **?**.

The above method to set the configuration of the computer is only temporary; it works only for the current session. The permanent settings are

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[8] Additional information on the Kermit protocol and program can be found in the book Kermit: A File Transfer Protocol.

contained in the file MSKERMIT.INI which is used by the Kermit program when it is started. To change these settings use a text editor, such as the DOS 5.0 EDIT program, and modify the appropriate lines in the MSKERMIT.INI file. Semicolons in this file are comment lines and Kermit ignores these lines when reading the initialization file. In order to change the modem speed look for the line containing SET SPEED 9600; delete the semicolon and change 9600 to the proper speed. The communications port, terminal type, parity, and other parameters may be changed in the initialization file to customize the program. Additional information on each of these commands is conatained in the MSKERMIT.DOC and MSKERMIT.INI files discussed above.

One feature of the Kermit program is that any command may be entered by entering the first few characters which uniquely identify the command and pressing the <Esc> key. Kermit will then complete the remaining part of the command and wait for the user to compete the command. As an example when the user types **CON<Esc>** the Kermit program will complete the phrase CONnect and wait for the user to enter the appropriate parameters.

b. Dial the NPS mainframe computer by typing **connect** to start the terminal mode. When the terminal mode has started type **ATDT phonenum** where phonenum is the dialing sequence you use to dial (e.g., 646-2709 or 9,646-2709). The command ATDT instructs modems using the Hayes command set to dial the phone number using tones. Additional Hayes commands are listed in Table III.

c. When the modem is connected to the mainframe log in as normal except choose **L** when asked to select a terminal type.

d. Type **linkto kermit** and then type **kermit.**

e. When the NPS computer prompt changes to *VMS-KERMIT*> type **server.**

f. "Escape" back to the local file transfer by typing the escape character **<CTRL>-]** and then **C.**

g. Once back at the *MS-KERMIT* > prompt files may be sent or received using the **send** and **get** commands respectively.

h. To determine what files are on the remote host use the **remote dir** or **remote list** commands.

i. To change the remote working directory use the **remote cd** or **remote cwd** commands.

j. When all file transfers have been complete exit the file transfer program by typing **bye** or **finish** which removes the host from server mode. The bye

TABLE III Hayes Modem Commands (adapted from Dvorak, 1990)

Command/Options	Example	Function
AT	AT	Attention! must precede all commands except A/, A>, and +++
A	ATA	Forces modem to answer incoming call
A/	A/	Repeat last command once
A>	A>	Repeat last command until cancelled or successful
<any key>	<spacebar>	cancel dialing operation or repeat of command
DP DT Subcommands , "	ATDP 1234 ATDT 1234 ATDT 9,1234 ATDT 9,"NPS"	Dial using pulse mode Dial using tone mode (comma) pause 2 secs convert letters in quotes to numbers
H	ATH	hang up phone
M0 M1 M2 M3	ATM0 ATM1 ATM2 ATM3	speaker always off speaker on until carrier established speaker always on speaker on after las digit and unitl carrier established
E0 E1	ATE0 ATE1	Local echo off Local echo on
+++	+++	gets modem attention to allow AT command set to work while phone is "connected" - used when AT command does not take effect

command terminates the Kermit session and then logs the user out of the remote computer and returns the user to DOS. The finish command terminates the remote Kermit Server butr remains in the Kermit program. The user must then type **quit** to end kermit and log out of the remote session normally.

k. Type **logout** at the host prompt and the hangup the phone by typing **hangup**. Exit the local Kermit program by typing **exit** or **quit**.

3. **Questions for the Student**

   a. What command do you use to get to terminal mode?

   b. What does the escape sequence do when you are in terminal mode?

   c. What command do you give the remote host to make it a server?

   d. What commands can you use to terminate the remote host Kermit session? What are the difference between the two commands?

   d. How do you send a command to the remote host?

   e. How do you change the settings for your computer?

   f. What command do you use to exit the remote host?

   g. What command do you use to hang up the modem?

h. **Discuss and evaluate the use of the ? and <Esc> commands.**

E. FILE TRANSFER PROTOCOL (FTP)

1. Exercise Description

This experiment will take the student through logging into the NPS mainframe and using the file transfer protocol to transfer a file from a remote host to the local host. The student will explore the available commands in FTP and determine the uses for each of the commands.

2. Exercise Instructions

a. Log onto the mainframe using your account number and password.

b. Press the **<Control>** and **<Home>** keys at the same time to clear the screen.

c. Type **DDNLINK** at the VMS screen. This allows you to access the Defense Data Network through the mainframe computer port.

d. Type **FTP** to access the File Transfer Protocol program on the mainframe.

e. Type **OPEN <hostname>**[9] where <hostname> is the DNS name of the host you are trying to access.

f. The mainframe will attempt to open a connection to the host you are trying to access. This may take a significant amount of time depending on the loading of the DDN. Once you are connected the program will respond with *OPEN*. You are now ready to log into the remote host and transfer the file from the remote host to your host.

g. Respond to the *LOGIN:* prompt by typing **ANONYMOUS** and respond to the *PASSWORD* prompt with **GUEST**. This combination of username and password works for most hosts and allows the user limited access to host functions. A convention has been adopted by most system operators requesting the user to provide their actual user identity. This convention allows the administrators to gather information relating to interest in their system and the source of that interest. The NPS mainframe computer operating system use the "@" sign as a backspace character and therefore this will not transmit properly to remote hosts. In

[9] Several hosts which can be accessed are: WATSUN.CC.COLUMBIA.EDU, BBS.MPC.AF.MIL, and FTP.EFF.ORG.

order to send NPS usernames replace the "@" sign with a space.

h. Use the **PWD** command to determine the current directory.

i. Use the **LS** command to determine what files and subdirectories exists in the current directory. If there is a file named *LS-LR* this file contains a long recursive (hence the LR) listing of the contents of the remote disk. This file can be transferred to the local account and reviewedif it does not contain the suffix *.Z* (which indicates compressed files); this saves a great deal of time especially when a single directory can contain hundreds of files. If a *README, readme*, or *READ.ME* file exists is contains information which the system administrator feels is important to remote users. This file should be transferred to a local account and read for important information prior to performing any other operations on the remote computer.

j. Use the **CWD** command to change the current working directory to one of the subdirectories listed in the LS-LR file or by using the LS listing.

k. Again use the **PWD** command to ensure that the **CWD** command was successful.

l. Type **GET <remotename> <localname>**. This is the command to transfer a single file from the remote host to the local host. Multiple files can be transferred using the **MGET** command and specifying those files to be transferred.

m. The system will then take a short amount of time to transfer the file from the remote host to the local host. The program will respond with the information about the size of the file and how long it took to transfer it from the remote host to the local host.

n. Files may be transferred from the local host to the remote host using the **PUT** and **MPUT** commands in the same manner as GET and MGET were used.

o. To close the connection between the NPS mainframe and the local host type **CLOSE**. To exit the FTP program type **EXIT**.

p. Type **DDNDROP** to exit the DDN access program. A copy of the file should now show up in the local file list; this copy belongs to the local account and can be manipulated accordingly.

3. Questions for the Student

a. What command do you use to get help on the commands available in the FTP program?

b. What other commands are available for use from the FTP command?

c. What command would you use to change the working directory?

d. What command would you enter to determine the current directory?

e. What command would be used to display a directory of the files which are on the remote computer?

f. What does the PWD command show?

g. How do you transfer a file from the remote host to the local host?

h. How do you transfer multiple files?

i. What command to you enter to close the connection to the remote host?

F. USING TELNET TO ACCESS A MUSE

1. Exercise Description

The following experiment will take the student through the process of logging on to a host computer as a guest and exploring the MUD environment. The MUD being used is the MicroMuse At MIT which is an educational MUD used to teach the concepts of MUD systems. Once logged onto the host computer the student will be required to find the contents of a several locations in the fictional environment of the MUSE.

2. Exercise Instructions

a. Before proceeding with the TELNET session download the "CyberCit.txt" file from the host at MIT using anonymous FTP. This file describes the "environment" you will be wandering around while using the MUSE.

b. Type **DDNLINK** to gain access to the DDN through the NPS mainframe computer.

c. Type **OPEN <hostaddress>** where <hostaddress> is the address for MICHAEL.AI.MIT.EDU.

d. Log into the guest account on the MUD by typing *guest* at the "LOGIN:" prompt. No password is needed for the guest account, however access to certain functions will be limited due to guest privileges.

e. The opening banner will give information on changes to the system and provide two means for accessing the system. Choose the TinyTalk option to perform the remainder of the exercise.

f. Type the **look** command to "see" what is in the immediate area around you.

g. **Look** at each object in the room. The description of the object may contain information on how to use the object or may simply be a description of the visual aspects of the object.

h. Type the command **look self** to see what characteristics are assigned to current player.

i. Change the description of the current character by typing **@describe me=***newdescription*. Confirm that the description has changed by using **look self** again.

j. Use the **take** *object* command to pick up an object. If it cannot be picked up the system will state this.

k. Enter the command **exit** *name* or simply **name** where name is the item listed under Exits to move from the current area to another area. The items listed under the **Exits** caption are ways to move from the current space to another space. The words *port*, *starboard*, *spinward*, or *antispinward* are directional commands -- they move the player in the named direction within the same area.

l. Type the command **home** to go to the guest hotel.

m. Type **money** to determine the amount of money the current character has. Guest characters are not allow to spend or earn money; only registered users are allowed to do this.

n. Type the **who** command to determine who else is on the system.

o. Use the **say** *phrase* command to say something to other characters in the same area.

p. When finished with the session type **QUIT** in all uppercase letters.

3. **Questions for the Student**

   a. What address would you use to send a request for a permanent account on the system?

   b. What two command structures (operating environments) are available?

   c. Which of the two command structures is recommended for beginners? (use this command set to answer the remaining questions)

   d. What is your character name for the logon session?

   e. What commands are available for you to use?

   f. How do you find out who else is logged into the system?

   g. How do you talk to other people in the system?

   h. Set your characters' description to something other than it currently is. What commands did you use?

   i. How much money does your character currently have?

   j. What does the Weathered Parchment say?

   k. Where can Romillith take you?

   l. How do you get to the hotel?

   m. How do you register as a guest in the hotel?

n. What section and arc do you find the rain forest in?

o. What are the contents of the Ground Level of the Rain Forest?

p. What happens when you look at the Toucan?

q. Describe some potential uses of this technology in the military environment.

G. TRAINING A DISCRETE SPEECH SYSTEM

1. Exercise description

This experiment will introduce the student to the training of a discrete speech system hosted on an IBM compatible microcomputer. The speech recognition system being used for this experiment is the Dragon Dictate system. This system is a discrete speech, speaker dependent system capable of using an 80,000 word dictionary of words. The user must first train the system to recognize the control phrases for the system itself and then may use the system for controlling any application which uses keyboard entry.

2. Exercise Instructions

NOTE: The process of training the Dragon Dictate system will take approximately 1/2 hour. Training can be interrupted and resumed if necessary by choosing

"QUIT" and then choosing "SAVE" to save your voice models. When the session is resumed training will pick up where it was abandoned.

a. Turn on the computer which hosts the speech recognition system.

b. After the computer has run through the boot procedure type ***DT /S /D name*** where name is the name you will use for this experiment. Be sure to use a unique name (or phrase) to ensure that the system will create a new vocabulary for you.

c. Type TRAIN to initiate the training sequence. (The parameters of the system are set to use 3 repetitions of each phrase to build the necessary templates for higher recognition rates.)

d. Place the headset on with the microphone adjusted to be about 1 1/2" from your mouth. Follow the instructions on the screen to train ALL of the words in the system vocabulary.

e. Remember to speak in a normal voice and say the words as you would in normal use. This is very important to increase the recognition rate of the system.

f. when training is complete type SAVE to save the templates to the hard disk. BE SURE TO DO THIS

PRIOR TO TURNING THE COMPUTER OFF OR ALL YOUR WORK WILL BE LOST.

3. Using Discrete Speech System to Control the Computer

a. If the computer is already turned on and the speech recognition system is operating press the keypad plus sign and type ***N*** for new user and type your unique username.

b. If the system is not turned on turn it on and start the system by typing ***DT /S /D name*** where ***name*** is the name you used when training the system. The /S turns the microphone on and the /D name command loads the dictionary with your voice models in it.

c. Once the system has loaded you're vocabulary activate the system by saying *"VOICE CONSOLE"* and then ***"WAKE UP"***. You are now ready to use the system. Table IV provides a list of important keystrokes and phrases to use while using the system. More information on the operation of the system can be found in the Dragon Dictate Users Manual.[Dragon Systems, 1991]

d. Templates have been created to allow the Dragon Dictate system to work with different applications. These include:

TABLE IV Dragon Dictate Keystroke Commands

{alt key}	{move left 1}
{back 1}	{move left 2}
{back 2}	{move left 3}
{back 3)	{move left 4}
{back 4}	{move left 5}
{back 5}	{move up 10}
{backspace key}	{no thank you} *answer prompt n*
{back tab}	{num lock}
{close quote}	{zero} *1*
{close single quote}	{one} *2*
{comma}	.
{control key}	.
{delete key}	.
{dot}	{ten} *10*
{down arrow}	{open quote} *"*
{end key}	{open single quote} *'*
{enter key}	{page down}
{escape key}	{page up}
{function 1}	{point}
{function 2}	{right arrow}
.	{scroll lock}
.	{shift key}
{function 12}	{space bar}
{home key}	{tab key}
{insert key}	{up arrow}
{left arrow}	{yes please} *answer prompt y*

WordPerfect:

A commercial word processing program

Procomm Plus:

A commercial communications program

ROBOT:

A simulation of navigating a robot around a maze.

e. WordPerfect may be starting by saying "*START WORDPERFECT*" as one phrase. If this is the first time this phrase is used the system may not recognize it. Say "*BEGIN SPELL MODE*"[10] and position the cursor over the word the system "recognized". Type the "[" key and the first few letters of START. The system should recognized the phrase within the first several keystrokes. When the phrase [START WORD PERFECT] appears on the screen type the corresponding function key[11].

f. Once WordPerfect has started, anything you say (which the system recognizes) will be entered as though you were typing the characters at the keyboard.

---

[10] Another option for correcting words is to use the phrase "*OOPS*" and using the same process as described above.

[11] If a word is misspoken use either correction method and say "*CHOOSE 10*" tc reject the word completely. This is important to ensure the recognition rate of the system stays high.

TABLE V Dragon Dictate Commands for WordPerfect

start word perfect	quit word perfect	main menu
open document	close document	list files
save document	print document	get help
search for	search again	search and replace
search forward	search backward	
word left	word right	beginning of line
word left 1	word right 1	end of line
word left 2	word right 2	
word left 3	word right 3	
word left 4	word right 4	
word left 5	word right 5	
delete word	delete line	
normal text	underline text	new page
bold text	center text	
overtype mode	insert mode	
numeral 1	numeral 2	numeral 3
numeral 4	numeral 5	numeral 6
numeral 7	numeral 8	numeral 9
numeral 0		
begin block	delete block	copy block
end block	cut block	insert block
open window	close window	
next window	next document	
today's date		

TABLE VI Dragon Dictate Commands for Navigating Robot

activate robot	deactivate robot
gauges on	gauges off
map on	map off
compass on	compass off
camera on	camera off
move forward	move backward
turn left	turn right
camera left	camera right
discrete control	continuous control
weapon on	weapon off
fire	

g. There is a set of control words which can be used to control the unique functions of WordPerfect. Table V lists these phrases.

h. When finished with the WordPerfect Application quit the program and say "*ROBOT*" then "*ENTER KEY*" to start the robot application. The commands for navigation of the robot are shown in Table VI.

i. Navigate the robot around the maze as pictured in Figure 5.

j. When the "batteries" have run down the gauges and camera will go blank and finally the robot will quit operating. When this happens simply say "*QUIT*" and you will be returned to the DOS prompt.

Before exiting the system "SAVE" your voice models.

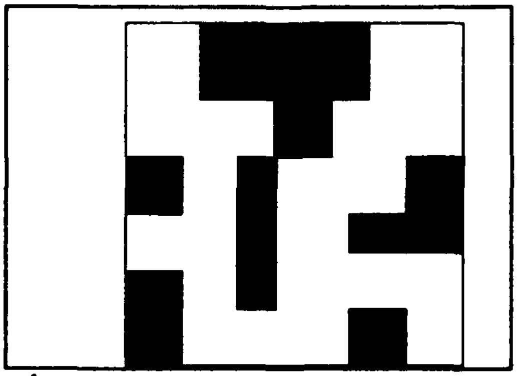

Figure 6 Maze for Robot Navigation

H. BIOMETRICS DEVICES

1. Exercise Description

This set of exercises will introduce the student to several of the biometrics devices identified in the text of the thesis. The student will then compare and contrast these devices.

2. Exercises

a. *Hand Geometry*

The hand geometry device is a biometric device which scans the shape of a person's right hand and compares the pattern with a stored pattern. If the patterns match, the user is authenticated. This device can be used to control keyless entry systems and also control access to computer systems with the proper interface. In this exercise the student will be enrolled into the scanner database and will complete a number of attempts to verify their identity using the hand geometry system. The students will also be required to enter another persons identity and attempt to improperly gain access to the system.

Before exiting the system "SAVE" your voice models.

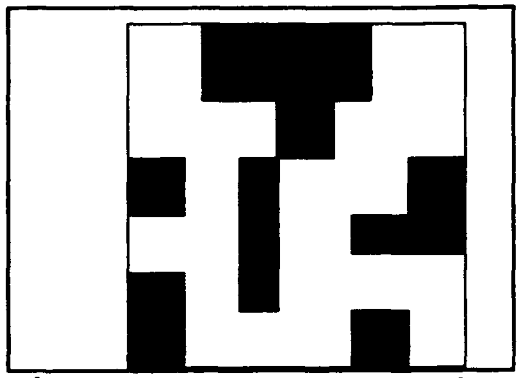

Figure 6 Maze for Robot Navigation

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(3) Attempt logon using another students user identification code a minimum of 5 times per day for a minimum of two days.

3. Questions for the Student

a. Write a paragraph on each of the devices used in the experiment listing the pros and cons of the device.

b. Which system would be best for use in an exposed environment (i.e., mounted on a wall with no protection from the elements)?

c. What system should provide the best performance for personnel in chemical suits?

d. Which of the devices is easiest to use?

e. Which one provides the greatest level of security?

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